U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 209.

B. T. GALLOWAY, *Chief of Bureau.*

GRIMM ALFALFA AND ITS UTILIZATION IN THE NORTHWEST.

BY

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ISSUED MAY 27, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 9, 1911.

Sir: I have the honor to transmit the accompanying manuscript, entitled "Grimm Alfalfa and Its Utilization in the Northwest," and to recommend that it be published as Bulletin No. 209 of the special series of this Bureau. This paper was prepared by Mr. Charles J. Brand while Physiologist in Charge of Clover and Alfalfa Investigations, Crop Physiology and Breeding Investigations, and has been submitted by Mr. Walter T. Swingle, Physiologist in Charge, with a view to publication.

A general belief has prevailed for a long time that alfalfa, because of its lack of winter resistance, could never have the wide utilization in the Northwest that it enjoys in the States farther west and south. Repeated attempts in the cold, humid Northern States to grow the ordinary American sort, which is of South American origin, have usually resulted in discouraging failures, and conclusive experimental evidence has been lacking on which to base recommendations of other kinds.

The experiments that have been conducted leave no doubt that only a very few strains of alfalfa can be expected to succeed regularly in regions where severe winter conditions prevail. Of these Grimm alfalfa has proved to be the best, both in the experiments of investigators and in the experience of practical farmers.

The investigations of the Department of Agriculture and of the Minnesota, South Dakota, and North Dakota experiment stations and many experiments in cooperation with private individuals all point to the great value of this strain. Several thousand acres of Grimm alfalfa are now under cultivation, giving a basis for seed production of the greatest value. It is the purpose of the present bulletin to bring about the general utilization of this strain in the large area to which it is suited by arousing widespread interest in it and fostering seed production. The proper utilization of Grimm alfalfa should result in time in a great addition to the annual value of our agricultural products.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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GRIMM ALFALFA AND ITS UTILIZATION IN THE NORTHWEST.

INTRODUCTION.

Grimm alfalfa is distinguished from other strains or varieties chiefly by its resistance to the severe winter conditions of the northern United States, including North Dakota, South Dakota, Minnesota, Wisconsin, Michigan, New York, Pennsylvania, and New England; also the northern portions of Nebraska, Iowa, Illinois, Indiana, and Ohio, and parts of Montana.

In his annual report for 1907 the Secretary of Agriculture predicted that the extension of alfalfa over large areas where it is not grown at present would be a prize worth hundreds of millions of dollars yearly. There are three great areas of the United States where up to now regular success has not been attained in the growing of alfalfa. These briefly are (1) the humid Eastern and Southern States; (2) those parts of the semiarid region where irrigation water is not available, especially in the drier parts of the Great Plains and Intermountain country; and (3) the northern part of the United States with its severe winter climate. The general extension of alfalfa over any or all of these great areas will certainly mean the addition of many millions to the annual value of our agricultural products.

It is believed that in Grimm alfalfa we have a race of almost inestimable value for at least one of these areas—the cold northern country. This variety is of such unusual promise that it seems desirable to give a fairly complete account of its history, behavior, and possibilities.

WENDELIN GRIMM.

Wendelin Grimm, who introduced alfalfa into Minnesota in 1857,[a] was born in October, 1818, in the little village of Külsheim, in the northern part of the Grand Duchy of Baden. This little German settlement is located in a splendid agricultural section about midway between Wertheim on the Main and Bischofsheim on the Tauber. Grimm lived at Külsheim until the spring of 1857, when he was in the

[a] A brief account of the history of Grimm alfalfa by the present writer appeared in Science, n. s., vol. 28, December, 1908, pp. 891–892, under the title "The Acclimatization of an Alfalfa Variety in Minnesota."

fortieth year of his age. Like so many sturdy German farmers, he looked to America as the land of great opportunities and decided to seek his fortune there. In May, 1857, he left Baden, determined to go to Minnesota, a State in which many of his countrymen had made new homes. He reached Chaska, Carver County, Minn., about September 1, and located on the northwest quarter of section 4, township 116 north, range 24 west, in Laketown. The substantial home that he built there later is still standing, though now under different ownership.

The old farm contained only 137 acres, but under Grimm's thrifty management it yielded a good living and sufficient profit so that in 1876 a more desirable place near town was purchased. On the new farm, which is now owned by his son-in-law, Mr. Grimm spent the remainder of his days. He died in December, 1891, at the age of 73 years. At this time his alfalfa had not yet attracted more than neighborhood attention, hence exact details as to his experience are lacking. The account given here has been secured from his sons Frank and Joseph and from a number of his neighbors. His sons agree that the original lot of seed brought from Germany did not weigh more than 15 or 20 pounds. This seed was sown in the spring of 1858.

Joseph Grimm, the elder son, says: "Six years after planting this clover my father built a bank barn on this place about 12 feet above level ground. We had to dig a driveway 10 feet deep to get into this barn, and we found the roots of this clover had penetrated more than 10 feet deep through the clay soil. My father said this clover needed drained soil and would not do well on sandy or low ground."

Mr. George Du Toit, of Chaska, Minn., who became acquainted with Mr. Grimm over thirty-five years ago and sold him many of his garden and field seeds, states that he was not an educated man, though he had the rudiments of a good German education. Mr. Du Toit says: "He was a splendid farmer, full of common sense, and determined in what he undertook."

Another old settler and neighbor to Mr. Grimm, Mr. Henry Gerdsen who is himself an excellent farmer, characterizes Mr. Grimm in a very similar manner. Mr. Gerdsen, who located in Carver County even earlier than Grimm, recounts some interesting stories of how Mr. Grimm's alfalfa proved its value in the early days. One of these stories deserves telling in this connection. The summers of 1863 and 1864 had been unusually dry, but in the spring of 1865 Grimm, on his way to market, drove past Gerdsen's place a small bunch of fat cattle. As feed was very scarce and his own and other neighbors' cattle were lean, Mr. Gerdsen expressed his surprise and asked how the stock had been fattened, saying, "You must have grown corn." Mr. Grimm, who was even in that early day an alfalfa enthusiast, having become familiar with the great value of the crop in his German home,

straightened up and answered proudly, "Kein Körnchen, nur ewiger Klee" (Not one kernel, only everlasting clover).[a]

The section of Baden from which Mr. Grimm came is known as the Bauland (farmland). It extends, in general, from the valley of the Neckar to the valley of the Tauber and is one of the most intensively cultivated portions of Germany. Its soil is of Jurassic origin and is rich in shell lime.

DESCRIPTION OF GRIMM ALFALFA.

To the casual observer Grimm alfalfa looks very much like all other alfalfas, but on closer examination it is found to be considerably more diverse than most kinds, showing individuals of upright and decumbent growth next to one another and showing a greater diversity in flower color than prevails in common alfalfa. All alfalfa has a certain range of flower color, but the Grimm has more than most cultivated sorts. The origin of this diversity can probably be traced to crossing in middle Europe between cultivated fields of true alfalfa (*Medicago sativa*) and neighboring isolated wild plants of the yellow-flowered sickle lucern (*Medicago falcata*). These two species intercross with considerable freedom. The percentage of crossing that has taken place is necessarily very small because of the scarcity of plants of the wild parents. It is more or less evident in practically all European alfalfa, but especially in that which is imported from Germany, Austria, Roumania, and the Piedmont region of Italy. The Provence and Poitou alfalfas of France also show this kind of diversity to a large extent.[b]

Recently there has been considerable interesting discussion among alfalfa breeders as to the importance of the presence of this exceedingly small percentage of falcata blood in Grimm and other European alfalfas, and a belief has grown that the proportion of falcata blood determines directly the degree of hardiness of this strain of alfalfa. On this basis the greater the proportion of falcata in a strain the hardier it should be. Experiments by the writer have not borne out this view, as other strains which give evidence of a higher percentage of falcata blood have proved to be far less hardy than Grimm alfalfa. Still other varieties that show no indication whatever

[a] In various parts of Germany a number of different names are applied to alfalfa, but Mr. Grimm used the names common in Baden and the neighboring portions of Wurttemberg and Bavaria, namely, "ewiger Klee" (everlasting clover), referring to its perennial nature; other names are "Monatsklee" (monthly clover), referring to the frequency with which it can be cut; and "gemeine oder gebaute Luzerne" (common or cultivated alfalfa), in distinction to related species which occur wild scatteringly through this region and in fact through practically all of Europe and western Asia.

[b] Accurate statistics, prepared by Prof. L. R. Waldron, showing the extent of diversity in flower color for a large number of Old World strains of alfalfa, were published in Science, n. s., vol. 33, February, 1911, pp. 310–312, in an article entitled "Variegation of European Alfalfas."

of the presence of falcata influence, such as Mongolian alfalfa and Wheeler's acclimatized Turkestan alfalfa (S. Dak. No. 240), which was developed from Hansen's original importation, were much hardier than any except the Grimm that showed evidence of this cross. It seems possible, therefore, that the effect of occasional crossing with *M. falcata* has not been to transmit hardiness directly, but by producing diversity to give greater opportunity for the environment to develop a strain of greater hardiness. The value of diversity in this respect has recently been discussed by Mr. O. F. Cook.[a]

Inasmuch as *Medicago falcata* is a species which has extraordinarily wide distribution it must vary greatly in hardiness. It ranges north and south from Italy to middle Norway in Europe and from India to Siberia in Asia, and ranges east and west from England almost to Korea.[b] The strain that has perpetuated itself in the mild climate of Baden, where some of the choicest of the Rhine wines are produced and where the almond and walnut flourish, would probably not be able to transmit any noteworthy degree of hardiness, but would by reason of cross-fertilization with *Medicago sativa* be extremely valuable in producing diversity. Hence it appears that Grimm alfalfa as it exists to-day is a direct product of diversity and selection due to environment. Through a period of 50 years lines of descent unfit to endure severe winter conditions have been eliminated, while fit lines have been perpetuated. The term "selective acclimatization" has been applied[c] to this process.

In another place[d] attention has been called to the fact that cultivated alfalfa is composed of numerous diverse strains, some of them being sufficiently distinct to constitute varieties or possibly even subspecies. These different races have very different forage and seed-producing values. The diversity of Grimm alfalfa as to certain characters is greater than that of our common western alfalfa. This is not so true of its habit of growth, leafage, etc., as it is of the color of the flower heads. In respect to this Grimm alfalfa is more diverse than any of our ordinary American or Chilean alfalfa.[e] It is no more diverse than some and but little more diverse than other

[a] Cook, O. F. Aspects of Kinetic Evolution. Proceedings of the Washington Academy of Sciences, vol. 8, February, 1907, pp. 197–403.

[b] Matsuda, S. On Medicago Sativa and the Species of Medicago in China. Botanical Magazine, Tokyo, vol. 21, No. 251, December, 1907, pp. 317–328. (In Japanese.)

[c] Brand, C. J., and Waldron, L. R. Cold Resistance of Alfalfa and Some Factors Influencing It. Bulletin 185, Bureau of Plant Industry, 1910, p. 67.

[d] Brand, C. J. Peruvian Alfalfa: A New Long-Season Variety for the Southwest. Bulletin 118, Bureau of Plant Industry, p. 18.

[e] Attention was first directed to this diversity in flower color by Mr. J. M. Westgate, of the Bureau of Plant Industry, who gives an extended discussion of it in Bulletin 169 of this Bureau, entitled "Variegated Alfalfa."

strains of common alfalfa grown in middle Europe, such as the "alt-deutsche fränkische," the Eifeler, the Pfalzer, and certain other kinds including notably the Provence and Poitou alfalfas of France and the strain secured from the Piedmont region of Italy.

The usual range of flower color in our common alfalfa includes violet,[a] lavender, purple, light indigo blue with tinges of purple and violet, and sometimes in older flower heads a tendency to paleness, resembling cream color. These colors are given in the order of their frequency of occurrence. In Grimm alfalfa these same color types predominate, but there is present a small percentage of at least three other elements which are as follows:

(1) Heads of variegated colors, generally light lavender or Nile blue, with a malachite-green tinge and indigo-blue veins on the standard; the basal flowers cream colored or whitish, with a tinge of pale green.

(2) The characteristic blackish or smoky-colored flowers that occur in such profusion when the wild, yellow-flowered *Medicago falcata* (sickle lucern) is crossed with the cultivated alfalfa (*Medicago sativa*). This flower color is very uncommon in Grimm and traces its presence to the next color element mentioned below.

(3) Light yellow-colored flower heads. These are of extremely rare occurrence and the number varies somewhat with the different cuttings, depending upon the character of weather that prevails. During the summer of 1909 a field of about 30 acres was carefully examined and only about 15 yellow-flowered plants were discovered.

The occasional crossing at some time with the yellow-flowered plants explains the rest of the diversity in color that Grimm and European alfalfas show as compared to our ordinary form from South America. This diversity in color probably arose from chance crossing in Europe between wild plants of the sickle lucern growing near fields of cultivated alfalfa. The percentage of procumbent plants present in the Grimm strain does not exceed that which occurs in many of our other cultivated alfalfas and is probably much less than that of most Turkestan alfalfas, large quantities of which are now used yearly by American farmers.

WHAT RACE WAS THE PROGENITOR OF GRIMM ALFALFA?

Külsheim, Grimm's home, is less than a hundred miles distant from that part of the Rhine Valley in the Bavarian Palatinate (Pfalz) where alfalfa was first introduced into Germany, according to Heresbach, about 1570.[b]

[a] The names of colors are based on The Nomenclature of Colors, by Robert Ridgway, Boston, 1886.

[b] Langethal, C. E. Handbuch der Landwirthschaftlichen Pflanzenkunde und des Pflanzenbaues, Klee und Wickpflanzen Berlin, 1874, p. 6.

In the valley of the Tauber in Wurttemberg and Baden, known as the Taubergrund, a highly prized strain of alfalfa has been grown for several centuries. This strain is called old German or old German Franconian lucern (alt-deutsche oder alt-deutsche fränkische Luzerne). This is the strain grown by Grimm's kinspeople who still live at Külsheim. It is considered far more valuable than the Provence or French lucern and its seed brings a much higher price. The Department of Agriculture, through the writer, has succeeded recently in securing a number of lots of seed of this variety. These are described in the inventories of the Office of Seed and Plant Introduction.[a]

At the request of the writer, Mr. Ludwig Keller, of Oberschüpf, Baden, made some inquiries into the history of old German Franconian alfalfa. The following, in free translation, is quoted from his report:

> This lucern was probably introduced into this country [Germany] at a very early time. It has adapted itself to the existing local conditions and has developed into a special strain of a certain constancy. Doubtless it is the same alfalfa that Farmer Grimm took with him to America. No other form is cultivated in our section on account of the superiority of this one.

This strain of alfalfa has now been grown for three seasons in this country in comparison with the Grimm variety, and their botanical identity is undoubted. It seems, therefore, that the highly prized old German form is truly the progenitor of the Grimm strain. Mr. Alois Grimm, of Külsheim, Baden, a kinsman of Wendelin Grimm, in a letter dated November 5, 1908, states that he grows the old German Franconian strain by preference and that other kinds than this and the Provence are unknown in his region. He also calls attention to the fact that a seed-grower's union has been established to foster seed production of the old Franconian variety.

According to Professor Wagner,[b] of Ettelbrück, Luxemburg, there is no doubt that this strain, both through long cultivation and because of care employed in the methods of seed production, has become acclimated to endure more extreme conditions. According to him its stands usually last from eight to twelve years, while the Provence lucern begins to get much thinner in three or four years, so that it is soon necessary to plow it up. Farmers in this region make a practice of saving seed from old stands in order to have the benefit of selection in getting rid of the weaker individuals.

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[a] Bulletin 137, Bureau of Plant Industry. Seeds and Plants Imported, Inventory No. 14, January, 1909, p. 56, and Bulletin 162 of the same series, Inventory No.18, December, 1909, p. 42.

[b] Wagner, J. P. Der Luzernebau und seine Wiederbelebung. Berlin and Brandenburg, 1905.

CLIMATIC CONDITIONS ENDURED BY GRIMM ALFALFA.

A brief study of the climate of the part of Baden from which Mr. Grimm brought his alfalfa makes possible a comparison with the Minnesota climate that it has endured since 1858.

Accustomed to the vastness of our own country, we often forget that the whole area of Germany is only two and a half times greater than that of Kansas. It follows that Germany does not possess the wide diversity of climatic conditions that characterizes the United States. Baden itself has only a little more than two-thirds the area of Vermont and comprises the warmest part of Germany. The grapevine is extensively cultivated, and Wertheim, near Mr. Grimm's old home, is the seat of production of the well-known Wertheimer wines. The whole valley of the Tauber produces wines which are generally designated under the name of "Tauberwein." Small as Baden is, more than 250,000 acres of the Grand Duchy are devoted to alfalfa and clover culture.

For Wertheim, only 6 or 7 miles distant from Külsheim, temperature records that extend back to 1873 are available. No records exist for any point as near as Wertheim to Külsheim for the period preceding 1857, but the interim between 1873 and the present makes fairly certain the nature of the climate over a long period. Table I gives a comparison between certain features of the climate of Wertheim with other points in Germany and in the United States, including St. Paul.

TABLE I.—*Mean monthly, annual (mean and extremes), and mean winter temperatures for St. Paul, Minn., Wertheim, Germany, and certain other places.* [a]

Station.	Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Winter, mean.
														Mean.	Maximum.	Minimum.	
		°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
St. Paul, Minn	.....	12	16	29	48	60	66	74	72	62	50	32	20	45	104	−41	16
Wertheim, Baden	1873–1907	32	33	39	48	56	62	65	63	57	48	38	34	48	95	−22	33
Santa Fe, N. Mex	.....	29	32	40	47	56	66	69	68	61	51	39	31	49	97	−13	30
St. Louis, Mo	.....	32	34	44	57	66	76	80	78	70	59	44	36	56	107	−22	34
Bismarck, N. Dak	.....	7	9	22	43	59	64	70	68	57	44	26	15	40	106	−44	10
Mergentheim, Württemberg	.....	29	35	39	49	57	64	66	65	58	48	38	32	48	.....	−19	32
Manhattan, Kans	.....	26	30	40	54	64	73	78	76	68	55	40	30	53	115	−32	29
Berlin, Germany	1719–1848	30	33	38	47	56	63	65	64	58	48	39	34	48	100	−20	32
Do	1848–1907	31	34	39	48	57	64	66	65	58	49	39	33	49	99	−13	33
Breslau, Germany	1791–1854	27	30	35	46	55	61	64	64	56	48	37	30	46	100	−19	29
Prague, Austria	1851–1890	30	32	38	47	56	63	67	65	59	49	38	31	48	94	− 7	31

[a] In the preparation of this table the official reports of the United States Weather Bureau and of the meterological bureau of the Grand Duchy of Baden, as well as monographs of Platz, Singer, Behre, Galle, and others have been utilized. Berlin, Breslau, and Prague were added to the table to show the general type of climate that prevails throughout middle Europe.

It will be seen from the mean temperatures shown in Table I that the winter climate of Wertheim is far milder than that of St. Paul, so much milder, in fact, that it is surprising to see a strain of the hardiness of the Grimm originate under such conditions. Grimm alfalfa in the beginning did not have the high percentage of hardy individuals that it now possesses. This is apparent on examining some of the old fields of this strain in Carver County, which range in age from 12 to 40 years, and also by comparing its behavior under identical conditions with the "alt-deutsche fränkische Luzerne," from which there is strong reason to believe it sprang. The old fields have gradually deteriorated in stand until only the hardiest individuals remain.[a]

Plate I, figure 1, from a photograph of a 25-year-old field on the Bender farm near Chaska, Minn., shows only partially the selective elimination which this field has endured. Not all of the plants that remain are as old as the stand itself. In fact, there is strong reason for believing that a considerable part of the plants now in the stands originated from seed that fell from older plants.

In comparative experiments with Grimm alfalfa and the old German Franconian alfalfa the latter has proved to be much less hardy under our northern conditions than the Grimm, which points to the probability that the German lucern that Mr. Grimm brought with him has been greatly modified during its fifty years' sojourn in Minnesota. In an experiment at Dickinson, N. Dak., under identical conditions and with identical treatment, adjoining rows of these strains killed out very differently. In the old German strain 64 out of 85 plants winterkilled, while in a sample of Grimm grown in North Dakota only 2 out of 70 plants were killed. In other words, the Grimm killed out less than 3 per cent, while the old German lost more than 75 per cent.

To further characterize the climate of Baden and some other European points as compared with our own climate, Table II, showing the absolute minima for a period of years, is inserted.

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[a] In a letter to the writer dated October 18, 1909, Mr. George Du Toit made the following statement: "I had called on him [Grimm] many times in driving by his farm a few miles from town, and became much interested in his determined efforts to raise an alfalfa that would stand our severe climate. He told me about his bringing a few pounds of seed with him when he came to this country from Baden, where he was born, and the time he had to save a portion of his seed, as time and time again the severe cold of those days killed it out. But he was a determined man * * * and kept at it until finally he won out and at last had a 'Grimm strain' that would stand our climate. Then gradually his neighbors followed him when they saw the great value of this clover, and to-day you can scarcely find a farm in Carver County that doesn't have a field of alfalfa." Mr. Du Toit was under the impression that Mr. Grimm had later sent back to Germany for seed, but inquiries addressed to his relatives and others fail to confirm this belief.

TABLE II.—*The lowest temperatures for each year for St. Paul, Minn., Wertheim, Germany, and certain other places, 1873 to 1907.*

Year.	St. Paul, Minn.	Wertheim, Baden.	Santa Fe, N. Mex.	Mergentheim, Wurttemberg.	Bismarck, N. Dak.	St. Louis, Mo.
	°F.	°F.	°F.	°F.	°F.	°F.
1873	− 33	13	− 2	7	.....	− 23
1874	− 23	− 1	0	− 1	.....	− 2
1875	− 32	− 7	2	− 7	− 34	− 18
1876	− 27	4	− 1	− 1	− 30	− 5
1877	− 24	6	2	7	− 30	− 6
1878	− 13	7	− 2	3	− 20	− 6
1879	− 39	− 9	− 13	− 16	− 38	− 16
1880	− 27	− 10	− 11	− 11	− 28	− 6
1881	− 25	− 10	− 9	− 11	− 34	− 12
1882	− 18	12	− 1	7	− 24	− 6
1883	− 31	10	− 13	12	− 37	− 4
1884	− 31	9	− 2	3	− 40	− 22
1885	− 36	2	− 3	0	− 36	− 10
1886	− 34	5	− 6	4	− 37	− 8
1887	− 36	− 8	− 8	− 6	− 44	− 10
1888	− 41	− 8	− 2	− 17	− 37	− 12
1889	− 25	− 9	− 1	− 7	− 34	0
1890	− 22	4	2	5	− 35	4
1891	− 25	− 16	− 6	− 10	− 33	4
1892	− 25	− 3	1	− 6	− 34	− 2
1893	− 26	− 22	5	− 15	− 41	− 2
1894	− 25	5	0	3	− 33	− 11
1895	− 26	− 12	− 11	− 19	− 39	− 12
1896	− 18	13	7	12	− 23	5
1897	− 26	15	− 1	16	− 36	− 2
1898	− 19	16	− 6	18	− 18	3
1899	− 33	5	− 5	− 3	− 37	− 16
1900	− 18	15	7	14	− 33	1
1901	− 25	− 7	1	− 10	− 26	− 10
1902	− 18	7	8	5	− 29	− 2
1903	− 24	10	− 4	7	− 41	− 6
1904	− 33	14	0	9	− 35	− 6
1905	− 26	2	− 3	− 1	− 39	− 18
1906	− 17	10	0	6	− 28	5
1907	− 22	6	5	5	− 39	3
Average	− 26.4	1.9	− 2	0.06	− 33.4	− 6.5

A study of this table shows that in the period that elapsed between 1873 and 1907 only 13 winters at Wertheim had minima below zero Fahrenheit, while 22 had minima above zero. During the same period St. Paul has never experienced a single winter with a minimum above zero. Only once in thirty-five years did Wertheim's minimum fall below −20° F., while at St. Paul only 6 out of 35 winters had minima above −20° F. Only two of Wertheim's minima are lower than the highest minimum (−13° F. in 1878) experienced in St. Paul during the period. According to the record the lowest temperature ever experienced at Wertheim was −22° F., while the lowest at St. Paul was −41°. St. Louis, which has almost the same absolute minimum as Wertheim, has had only 7 winters since 1873 with minima above zero, as compared with 13 for Wertheim. Mergentheim, with an absolute minimum for the period of −19° F., is located more nearly at the center of seed production of alfalfa in Franconia (Franken) than Wertheim. Bismarck and St. Paul are inserted in the table to illustrate in a measure what alfalfa must endure in the way of low temperatures in a large part of our

Northwest. The test is a severe one. The data which have now been collected indicate that Grimm alfalfa will endure these conditions in a fuller measure than any other known cultivated variety of *Medicago sativa*. It came from a region where the mean duration of the frost period[a] is about forty days and has now for years been grown successfully in the Minnesota climate, where the mean duration of the frost period is almost one hundred and forty days.

The mean annual and mean winter temperatures for Wertheim and Berlin are almost identical (Table I), although Berlin is considerably farther north than Wertheim. According to Behre,[b] Berlin, in the sixty years that intervened between 1847 and 1907, experienced only 30 winters the mean temperatures of which fell below the freezing point. The coldest of these had a mean of only 27° F. (−3.3° C.). St. Paul, on the other hand, during a period of fifty-four years, extending from 1854 to 1908, did not experience a single winter with a mean as high as 32° F., against Berlin's 30 winters, and the mean of the warmest winter St. Paul[c] has experienced (27° F.) is identical with that of Berlin's coldest winter.

In the one hundred and seventy-eight years that intervened between 1729 and 1907 Berlin had a total of only forty-four days with minima of 0° F. or below. Minnesota not infrequently has as many days of severe weather in a single winter. The absolute minimum at Berlin in this long period was −20° F.

The winter mean (December, January, February) at Berlin is 33° F., identical with that of Wertheim and one degree warmer than

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[a] Dorscheid, O. Die mittlere Dauer des Frostes auf der Erde. Meteorologische Zeitschrift, Brunswick, 1907, vol. 24, pp. 60, 62.

The method of expressing severity of winter conditions by the duration of the frost period appears to be an unusually instructive one, especially for regions where the fluctuations between nocturnal and diurnal temperatures are not excessive, as is the case in all of the United States except in the arid regions. The duration of this period is found by determining the mean date on which the mean daily temperature passes below the line of the freezing point in autumn until it rises above this in spring. Hence the frost period as defined by Dorscheid extends from the day in autumn when the normal passes below 32° F. until the day in spring when it again rises above 32° F. These dates for Wertheim are December 18 and January 26, respectively, while for St. Paul they are November 11 and March 24, respectively. The mean duration of this same period for Salt Lake City, where common alfalfa is grown with perfect success, is fifty-two days, while for St. Louis, Mo., it is twenty-five days, and for Santa Fe, N. Mex., forty days. St. Paul's winter temperatures resemble rather closely those of St. Petersburg, Russia, while Wertheim's are similar to those of St. Louis, Mo., and of Santa Fe, N. Mex.

[b] Behre, O. Das Klima von Berlin, Berlin, 1908, p. 53.

[c] Stockman, William B. Invariability of Our Winter Climate. Monthly Weather Review, May, 1904. This short but excellent paper should be in the hands of every student of cold resistance in our crop plants. Reprints may be obtained by application to the Chief of the Weather Bureau, U. S. Dept. of Agriculture, Washington, D. C.

the November mean at St. Paul. In other words, the winter in Baden is about as cold as November in Minnesota. The winter mean for St. Paul from 1854 to 1904 is 13.4° F., while its coldest winter, that of 1874–75, had a mean of 3.7° F.—the winter that Mr. George Du Toit remembered as having been so destructive to Mr. Grimm's alfalfa. It seems almost axiomatic to say that Grimm alfalfa as it exists to-day is the product of a half century of the most rigorous selection for cold resistance endured by any race of alfalfa of which we have knowledge.

HARDINESS OF GRIMM ALFALFA IN COMPARISON WITH OTHER KINDS.

EARLY EXPERIENCES IN CARVER COUNTY.

The existence of a small localized alfalfa industry in Carver County, Minn., for more than a generation is of itself significant. If, as seems likely, the seed Mr. Grimm brought with him was the old German Franconian alfalfa, he had a somewhat superior basis on which to begin building a hardy race. The Provence and Poitou alfalfas of France, which occur in large quantities in commerce, would probably have presented somewhat greater difficulties in acclimatization. The great range of variation occurring in practically all kinds of alfalfa adapts this crop especially for acclimatization. Even our common alfalfa, in its progress eastward and northward to Nebraska and Montana, appears to have undergone a high degree of adaptation toward endurance of cold.[a] Indeed, such tender strains as the Peruvian and Arabian show great diversity in hardiness of individual plants. In fact, the Arabian alfalfa, which is the most sensitive to cold of any of which we have knowledge, is now being subjected to selection to produce a hardy strain of this valuable rapid-growing sort.

In addition to the advantage of a superior strain to begin with, Mr. Grimm had the characteristic German perseverence. In his first attempts he suffered many setbacks, and according to Mr. Charles Kenning, of Bird Island, Minn., he made but little headway for a number of years.[b]

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[a] See Bulletin 185, Bureau of Plant Industry, pp. 49–50.

[b] Mr. Kenning became acquainted with Grimm alfalfa at a very early date—1863 or 1864—and although he gives Mr. Grimm credit for developing it into a hardy strain, he does not believe that Grimm was the actual introducer. His recollections, as given in a recent letter to the writer, follow:

"From 1861 to 1864 I was employed in teaming, hauling wood mostly from a settlement of Swiss in the eastern part of Laketown, 6 miles north of Chaska, Carver County. During that time, I should judge in 1863, a family, relatives of one of the Swiss colony, immigrated to Minnesota, settling in the colony, bringing various kinds of seed from their native country, and among them alfalfa seed, or, as they called it, 'ewiger Klee,' meaning everlasting clover. What called my attention to this was the

At the 1903 meeting of the Minnesota State Agricultural Society, Kenning first told of his memory that Grimm's early attempts met with discouraging results and also stated his belief that the original seed was brought in by Swiss immigrants.[a] In 1904 Mr. Kenning again called attention to the matter in a letter published in the issue of March 1 of Farm, Stock, and Home (vol. 20, p. 112), stating: "For many years it [Grimm alfalfa] made but little headway and was too often a failure, but by persisting in saving every plant that could be saved it gained strength and seemed to acclimate, or possibly produced a new variety, until it is one of the surest clovers for that section [Carver County]."

The testimony of Mr. Grimm's immediate family and that of his old friends and neighbors who were in a position to know the facts leaves little room to doubt that he was the introducer, as well as the unconscious breeder, of the valuable alfalfa that bears his name.[b] From

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discussion and ridicule that was brought forth by the idea of growing clover in this frozen region. There was but one man, Wendelin Grimm, a native of Baden, Germany, who had the courage to give it a trial. He got a portion of the seed, which he sowed, the balance being sown by one of the Swiss. We had a rather hard winter, mostly killing out the plants, but the few that survived were carefully nursed by Mr. Grimm. As it was a good year for seed, Mr. Grimm got enough to sow a small patch the following year. This either proved more hardy or the season was more favorable and produced a good quantity of seed; it began also to interest others, who gave it a trial. In 1868 or 1869 I was present at a gathering of farmers at the brewery on the outskirts of Chaska. Among them was Mr. Grimm, and he was entertaining the farmers with a history of his success with this clover, which deeply interested all."

Many accounts have been circulated from time to time as to the origin of Grimm alfalfa, one seed firm even claiming to have furnished Mr. Grimm his original seed as late as 1892, although he died in 1891. Most of these accounts have been investigated and only Mr. Kenning's appears to deserve comment, as he knew Grimm personally and was familiar with his alfalfa for many years.

[a] Annual Report Minnesota State Agricultural Society, 1903, p. 40.

[b] In a letter dated Feb. 7, 1910, Mr. Kenning states that Mr. Gottlieb Plocher, of Victoria, Minn., who was a near neighbor and friend of Mr. Grimm, was very familiar with the origin of the latter's lucern seed and had grown it from the beginning. Mr. Plocher came to Minnesota from Germany in 1855, and knew Mr. Grimm from the time of his arrival in 1857 until he died in 1891. The following statement, in free translation, is taken from a German letter recently received from Mr. Plocher: "To my positive knowledge Grimm brought with him from Germany [Baden] a packet of 'ewiger Klee,' as he called it, and as it is still called to-day by many Germans. * * * As he was packing up at his old home before he emigrated he was in doubt as to whether or not he should take along the packet in question, as he was very short of space. Finally he decided to take it with him."

As long ago as 1872 or 1873 Tobias Ottinger, another of Grimm's neighbors, told Mr. Kenning that Mr. Grimm had brought the seed in with him. The accounts of Frank Grimm, the younger son, who still lives in Carver County, Minn., and of Joseph, the elder son, who lives in Florida, coincide exactly. The latter left Minnesota in 1876 and has been back only once in the interim, and that twenty-six years ago.

the very nature of the testimony at this late date there is abundant opportunity for different men to reach different conclusions.

Mr. George Du Toit, who in the early day sold Mr. Grimm many of his field and garden seeds, and later was president of the bank at which Mr. Grimm transacted business, tells of one particular spring, about 1875, that the latter stopped him as he was driving by his farm and told him of the killing out of his lucern. So badly had it fared during the preceding winter that Grimm felt himself extremely fortunate to have saved a small bag of seed of a previous year's growth, which he had hanging in the granary and which he showed to Mr. Du Toit.

Investigation of the weather records of Minnesota corroborates Mr. Du Toit's memory statement with regard to the severity of the winter of 1874–5. Its mean temperature was 3.7° F., the lowest mean recorded at St. Paul since 1854. Considering the comparative mildness of the climate whence Grimm brought his seed, there is little wonder that the selective effect of this particular winter was so disastrous, though other severe winters had intervened in Minnesota between 1858, the first seeding year of Grimm alfalfa, and 1875. Grimm's persistence and the evident value of the forage that he grew gradually led his neighbors into the culture of alfalfa.[a]

In 1865 the elder Grimm purchased a thrashing machine from an implement dealer, who advised him to produce as much alfalfa seed as possible and offered to sell all that he could raise. Joseph, who managed this thrashing machine for seven years, states that in 1867 his father produced 480 pounds of seed on 3 acres of land, which he thrashed with the machine and sold in Minneapolis for 50 cents a pound. This appears to be the first considerable quantity of seed ever produced and it is a matter of regret that it was sold out of the neighborhood.

From 1871 until 1890 gradual progress was made in the extension of alfalfa in Carver County. By this time the common alfalfa of Utah, New Mexico, and California had begun to attract considerable attention throughout the country, and much common alfalfa was tried in Minnesota.

In not infrequent years fair crops of seed were produced, but owing to the small demand the seed did not find ready sale, and it was

[a] Up to 1871 the extension of this alfalfa was very slow. This is explained by Joseph Grimm as being due to the fact that hitherto no law had existed which prevented the ranging of stock on vacant lands. In that year the Minnesota legislature passed a local stock law in accordance with whose provisions every township could vote to keep stock from running at large. According to Joseph, prior to 1865 practically no clover or alfalfa seed was planted in their neighborhood. as the cattle had plenty of open range to feed upon and the farmers needed their land for other crops.

commonly delivered to the local store in barter for household necessities. By the time of Mr. Grimm's death, in 1891, this condition had disappeared, and gradually most of his surplus seed went into the hands of neighbors and less to the local stores. Since 1890 much common alfalfa from Utah, Kansas, and California and imported seed obtained from the larger seed houses has been tested in this section, but there is no record of even one permanently successful effort with these strains of seed.

Still, there was no general recognition that the Grimm strain was more valuable than others, cultural treatment and other extraneous explanations being given as to the cause of failure in the growth of the ordinary kind. Grimm's own son-in-law some years later, when his brother wrote him for alfalfa seed, not having produced any himself that he could furnish, bought two bushels of the ordinary kind at the local store and sent it to him.

In 1899, with the exception of certain counties in New York, Carver was the only county east of the Mississippi and Missouri Rivers that reported as much as 1,000 acres of alfalfa under cultivation. By this time the reputation of Grimm's alfalfa began to be a little more than local, though its real value was not yet realized. In 1900, Mr. A. B. Lyman,[a] a Carver County farmer, whose farm is only a few miles distant from the Grimm farm, called the attention of Prof. Willet M. Hays, Assistant Secretary of Agriculture, who was at that time professor of agriculture in the University of Minnesota, to this strain of alfalfa and to his experience with it and with the ordinary kind. Professor Hays quickly recognized the probable value of the Grimm strain and made immediate efforts to extend its culture.

Mr. Lyman first saw the Grimm alfalfa in 1881, when, as a boy, he accompanied his father about the county. Later, in 1890, he taught school in a section of Carver County where practically all of the German farmers were growing alfalfa, which they called "ewiger Klee" (everlasting clover). Returning home at the close of his school term in spring he told of the great advantages of growing alfalfa. Accordingly, a quantity of commercial seed was purchased and sown on the home farm. The first season's growth was fine and the new seeding passed the first winter successfully. This is frequently the case, especially when seeded with grain, as the stubble holds sufficient snow to give the young plants protection. The hay yield of the second summer (the first crop year) was good, but during

[a] An account of Mr. Lyman's attempts to propagate seed of Grimm's alfalfa can be found in the annual report of the Minnesota State Agricultural Society for 1903, pp. 38–44.

the following winter the alfalfa all killed out. Lyman observed that the fields of the German farmers had not done likewise, and in 1894, in renewing his efforts to grow alfalfa, he used seed grown by them. The results of his new trial were entirely successful; ever since that time he has had Grimm alfalfa growing on his farm continuously. At one time as many as 100 of his 250 acres were devoted to the crop.

RECENT EXPERIENCES WITH GRIMM ALFALFA.

Recognition of the superiority of the Grimm variety over ordinary alfalfa by Mr. Lyman, and through him by Professor Hays, of the Minnesota station, marked a third era in the evolution of alfalfa culture in the Northwest. About this time Turkestan alfalfa, some strains of which have proved considerably hardier than common alfalfa, began to attract attention and probably somewhat retarded the development of a Grimm alfalfa industry. In 1901 experiments were begun with the Grimm variety on the Minnesota University farm, which attracted added attention to it. In a short paper published in 1904 Professor Hays[a] gave its history as then understood and predicted in a measure its potential value.

The reputation already acquired and the favorable mention accorded it from time to time in the agricultural papers of the Northwest and elsewhere immediately created such a demand for the seed that only a small fraction of it could be satisfied. The Minnesota climate, except in occasional years, is quite unfavorable for seed production, hence the available supply of seed has always been small. This condition has led to adulteration with seed of inferior strains in some cases and to the recommendation of substitutes in still others.

In 1904 the attention of the Department of Agriculture was directed to Grimm alfalfa and experiments with it were begun in 1905. The first lot of seed obtained by the department was received by the writer from Prof. J. H. Shepperd, of the North Dakota Agricultural Experiment Station, in October, 1904. Since that time it has been grown in comparison with a very large number of regional varieties, representing practically all of the more important alfalfa-producing regions of the world. Some of the results of these experiments are briefly given here. So far as known there is no case of record where the comparison was a fair one in which the hardiness of Grimm alfalfa has been exceeded by any other.

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[a] Hays, W. M. Hardy Alfalfa in Minnesota. Press Bulletin 21, Minnesota Agricultural Experiment Station, March, 1904.

EXPERIMENTS OF INVESTIGATORS.

EXPERIMENTS AT ST. ANTHONY PARK, MINN.

Comparison of varieties.—The Agricultural Experiment Station of the University of Minnesota was the first to compare Grimm alfalfa with other kinds. This work was begun in 1901 under the direction of Prof. Willet M. Hays, whose excellent statistical methods have been followed in all the experiments. His press bulletin on the subject is referred to above. The results as to winterkilling presented below for the first time were furnished by Mr. A. C. Arny, of the station staff, through the courtesy of Dr. A. F. Woods, dean and director, and Prof. Andrew Boss, professor of agriculture in the University of Minnesota and agriculturist to the experiment station. The writer desires to acknowledge the energetic and efficient cooperation and assistance given by the Minnesota station through its various officers.

The severe winter conditions that prevail in the vicinity of Minneapolis and St. Paul, where the longest series of experiments with Grimm alfalfa has been carried on, have already been touched upon in a general way. The weather of individual winters during the progress of the work will be discussed briefly in their relation to the results obtained.

Experiments begun in the spring of 1901.—The first experiments for which data are available were begun in the spring of 1901. The following table shows the comparative behavior of the four alfalfas tested:

TABLE III.—*Winterkilling of alfalfa in experiments begun in 1901 at St. Anthony Park, Minn.*

Minnesota. No.	Source of seed.	Number of plants alive—		Percentage of winter loss.
		Autumn of 1901.	Spring of 1902.	
4	Carver County, Minn., Grimm (grown by A. B. Lyman)..	54	52	3.7
5	Commercial seed	79	50	36.7
6	....do	50	22	56.0
7	Iowa seed	65	55	15.4

The average loss of the three samples compared with the Grimm was 36 per cent. The loss of the Grimm was 3.7 per cent.

The winter of 1901–2 at Minneapolis was of average severity. The lowest temperature recorded was −27° F. The mean for the winter months (December, January, and February) was 17.6° F., while the mean of the minima for the same months was 9.6° F.

The following tabulation is designed to give the data as to temperature which have a direct bearing on studies of cold resistance:

TABLE IV.—*Temperatures at Minneapolis, Minn., November, 1901, to March, 1902, inclusive.*

Period.	Mean.	Mean of the minima.	Lowest temperature.	Days with minima below zero.
	°F.	°F.	°F.	*Number.*
November, 1901	31.0	22.4	12	0
December, 1901	15.9	8.5	−27	8
January, 1902	18.7	10.2	−17	7
February, 1902	18.2	10.1	−15	7
March, 1902	36.2	27.2	− 7	2
For the 5 months	24.0	15.7	−27	24
For December, January, and February	17.6	9.6	−27	22

The following brief summary shows the conditions that prevailed with reference to precipitation from the spring of 1901, when seeding was done, until the spring of 1902, when the determinations of winterkilling were made:

TABLE V.—*Precipitation at Minneapolis, Minn., April, 1901, to March, 1902.*

Period.	Precipitation.	
	Form.	Inches.
April to August, 1901	Rain	14.37
September to November, 1901	do	7.32
December, 1901, to March, 1902	do	.57
November, 1901, to March, 1902	Snow	19.90
Total for the entire period		24.25

The total rainfall of the growing season for this year was the lowest experienced during the years included in these experiments, 1901 to 1909. The total snowfall was also the lowest for the period.

Experiments begun in the spring of 1902.—In the spring of 1902 a varying number of hills, ranging from 94 hills in a supposed Grimm sample of unknown source to 6,298 hills in a sample known to be Grimm, was planted. Included among the 11 kinds were 5 strains of Grimm, 2 strains of Turkestan, and 4 samples of commercial seed of ordinary alfalfa. Three of the samples of commercial seed were produced in the 1901 experiments shown in Table III. Unfortunately the number of hills living in the fall of 1902 was not determined. A comparison of the total number of hills planted in the spring of 1902 with the number of hills alive in the spring of 1903 shows an average loss of 30.2 per cent for the 5 Grimm samples. The average for the 6 other samples was 43.4 per cent. Only a portion of the loss in these cases can be attributed to winterkilling. Table XI shows that the number of hills planted in spring is a very poor index of the number of hills alive in autumn.

The winter of 1902–3 was about 2 degrees colder than the normal for Minneapolis for a number of years. The lowest temperature recorded was −24° F., while the mean for the winter months was 15° F. The mean of the minima for the same months was 6.4° F. The following are the most important features of the weather during the winter of 1902–3:

TABLE VI.—*Temperatures at Minneapolis, Minn., November, 1902, to March, 1903.*

Period.	Mean.	Mean of the minima.	Lowest temperatures.	Days with minima below zero.
	° *F.*	° *F.*	° *F.*	*Number.*
November, 1902	36.0	30.6	17	0
December, 1902	15.6	8.1	−20	7
January, 1903	14.6	5.5	−14	11
February, 1903	14.8	5.6	−24	9
March, 1903	33.6	26.6	8	0
For the 5 months	22.9	15.3	−24	27
For December, January, and February	15.0	6.4	−24	27

It will be seen that the means of the minima for the winter months are rather low.

With reference to precipitation the following conditions prevailed from the spring of 1902 until the spring of 1903, when the number of living hills was determined, as shown in column 3 of Table VIII.

TABLE VII.—*Precipitation at Minneapolis, Minn., April, 1902, to March, 1903.*

Period.	Precipitation.	
	Form.	Inches.
April to August, 1902	Rain	20.59
September to November, 1902	do	6.71
December, 1902, to March, 1903	do	3.14
November, 1902, to March, 1903	Snow	27.40
Total for the entire period		33.18

This experiment was carried through a second season. The total loss suffered from all causes between the spring of 1903 and the spring of 1904 is shown in Table VIII.

TABLE VIII.—*Loss of alfalfa hills during 1903 and 1904 in experiments begun in 1902 at St. Anthony Park, Minn.*

Minnesota. No.	Source of seed.	Number of hills alive in spring of—		Percentage of loss 1903 and 1904.[a]
		1903.	1904.	
2	Turkestan Tashkend, S. P. I., No. 991	184	10	94.7
4*a*	Grimm from 1901 planting (Table III, No. 4) [b]	285	116	59.4
5*a*	Commercial seed from 1901 planting (Table III, No. 5)	441	11	97.5
6*a*	Commercial seed from 1901 planting (Table III, No. 6)	241	6	97.5
7*a*	Iowa seed from 1901 planting (Table III, No. 7)	139	5	96.4
11	Turkestan grown at Brookings, S. Dak., from S. P. I., No. 991	131	20	84.8
12	Variety unknown (Wayzata, Minn.)	270	65	75.9
13	Carver County, Minn., Grimm (grown by A. B. Lyman, 1901)	4,534	4,035	11.0
14	Carver County, Minn., Grimm (grown by A. B. Lyman, 1900)	1,472	1,249	15.2
15	do	1,332	1,056	20.7
16	Source unknown (supposed to be Grimm)	51	48	5.9
	SUMMARY (AVERAGE LOSSES).			
4*a*, 13, 14, 15	Grimm, 4 strains	7,623	6,456	26.5
2, 11	Turkestan, 2 strains	315	30	89.7
5*a*, 6*a*, 7*a*, 12	Commercial, 4 strains	1,091	87	91.8
16	Source unknown, 1 strain	51	48	5.9

[a] The plants were not counted in the autumns of 1902 and 1903, hence the percentage of loss given in column 5 represents loss due to all causes.

[b] The letters *a*, *b*, *c*, *d*, etc., affixed to certain numbers in this and other tables represent the successive seed generations through which the parent strain has passed.

The winter of 1903–4 was considerably more severe here than the normal winter, as may be seen by a comparison of the data given below with those given for St. Paul in Table I. The mean for the three winter months was 8.3° F., while the mean of the minima for the same number of months was 0.4° F. The total number of days having a minimum below zero was 42.

TABLE IX.—*Temperatures at Minneapolis, Minn., November, 1903, to March, 1904.*

Period.	Mean	Mean of the minima.	Lowest temperature.	Days with minima below zero.
	° *F.*	° *F.*	° *F.*	*Number.*
November, 1903	29.8	22.2	0	0
December, 1903	12.6	3.8	−19	12
January, 1904	7.3	.1	−33	12
February, 1904	5.1	−2.6	−19	17
March, 1904	27.7	21.0	− 4	1
For the 5 months	16.5	8.9	−33	42
For December, January, and February	8.3	.4	−33	41

The following conditions prevailed as to precipitation during the period from April, 1903, to March, 1904:

TABLE X.—*Precipitation at Minneapolis, Minn., April, 1903, to March, 1904.*

Period.	Precipitation.	
	Form.	Inches.
April to August, 1903	Rain	20.41
September to November, 1903	do	13.31
December, 1903, to March, 1904	do	.75
November, 1903, to March, 1904	Snow	31.50
Total for the entire period		37.62

As previously noted, the Grimm strains lost 26.5 per cent, the Turkestan and commercial varieties 91.1 per cent, and No. 16, the source of which is unknown, 5.9 per cent. It is the writer's belief that the excess of autumn moisture was a very important factor in winterkilling in this experiment.[a]

The percentage of loss in Grimm No. 4*a*, compared with its parent No. 4, as shown in Table III, suggests interesting and important possibilities. It will be noted that the original Grimm seed No. 4 killed out only 3.7 per cent, while its progeny 4*a* killed out 59.4 per cent. No. 4*a* was produced alongside of 3 nonhardy strains of ordinary alfalfa, which fact appears to have brought about a very notable deterioration in hardiness, due to cross-fertilization. As collateral evidence that this is really the case it will be noted that in Table VIII 3 uncontaminated strains of Grimm (Nos. 13, 14, and 15) and another hardy sample, No. 16, obtained at about the same time, suffered an average loss of only 13.2 per cent. Similar results have been observed in other experiments; hence, it is essential that growers of hardy alfalfa should keep their seed plats well isolated from fields of any nonhardy kinds in order to guard against cross-fertilization or mixing.

Experiments begun in the spring of 1905.—In the spring of 1905 another experiment, including 5 Grimms, 3 Turkestans, and 6 strains from ordinary commercial seed was begun. As in the experiments previously described the plants were set out in hills, the number of hills of each kind varying greatly. Table XI shows winterkilling for the winter of 1905–6 and total loss from 1906 to 1907.

One important point should be remembered in connection with the Grimm samples included in this experiment. All had been produced in previous experiments where they were grown alongside other

[a] Readers desiring a fuller discussion of the injurious effects of autumn moisture should consult Bulletin 185, Bureau of Plant Industry.

hardy strains. Hybridization undoubtedly took place and it is quite likely that deterioration resulted. Unfortunately no pure Grimm strain was included in this experiment as in the experiment begun in 1902. (See Table VIII.)

The surviving plants of the experiment begun in the spring of 1905 were left to endure the winter of 1906–7. The character of winter weather experienced by these survivors is discussed in connection with Table XIV. Regarding the loss suffered from the time of counting in the spring of 1906 until recounts were made in the spring of 1907, as shown in Table XI, it may be said that 718 Grimm plants were living in the spring of 1906, and 595 of the same Grimm plants were living in the spring of 1907. Only 39 hills of the varieties other than Grimm came through alive in the spring of 1906; 30 of these were still living in the spring of 1907.

TABLE XI.—*Winterkilling of alfalfas in experiments begun in 1905 at St. Anthony Park, Minn.*

Minnesota No.	Source of seed.	Hills planted in spring of 1905.	Hills alive in fall of 1905.	Hills alive in spring of 1906.	Winter loss, 1905–6.	Hills alive in spring of 1907.	Total loss, 1906–7.[a]
		Number.	*Number.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
4*b*	Grimm from 1902 planting (Table VIII, No. 4*a*)	386	346	88	74.6	75	14.8
5*b*	Commercial from 1902 planting (Table VIII, No. 5*a*)	62	58	8	86.2	7	12.5
13*a*	Grimm from 1902 planting (Table VIII, No. 13)	2,132	1,930	362	81.3	280	22.6
14*a*	Grimm from 1902 planting (Table VIII, No. 14)	1,328	1,229	183	85.2	171	6.6
15*a*	Grimm from 1902 planting (Table VIII, No. 15)	650	612	85	86.1	69	18.8
16*a*	Seed from 1902 planting (Table VIII, No. 16, original source unknown)	192	186	27	85.5	21	22.2
34	Commercial Turkestan	310	230	2	99.2	2	0.0
35	Montana	310	259	1	99.6	0	100.0
36	Utah	306	90	1	98.9	0	100.0
37	Colorado	396	227	0	100.0	.....	.....
38	Nebraska	272	201	0	100.0	.....	.....
1*a*	Turkestan grown at the Minnesota station from S. P. I. No. 991 (Minn. No. 1), received in 1898	120	100	0	100.0	.....	.....
2*a*	Turkestan grown at the Minnesota station from S. P. I. No. 991 (Minn. No. 2), received in 1900 (Table VIII, No. 2)	120	97	0	100.0	.....	.....
3	Commercial seed	120	115	0	100.0	.....	.....
	SUMMARY (AVERAGE LOSSES).						
4*b*, 13*a*, 14*a*, 15*a*	Grimm, 4 strains	4,496	4,117	718	81.8	595	15.7
5*b*, 16*a*, 34–38, 1*a*, 2*a*, 3	Other than Grimm, 10 strains	2,118	1,563	39	96.9	30	23.0
5*b*, 35–38, 3	Ordinary (other than Grimm), 6 strains	1,926	950	10	97.4	7	33.3
34, 1*a*, 2*a*	Turkestan, 3 strains	1,376	427	2	99.7	2	0.0

[a] As plants were not counted in the autumn of 1906, figures in last column include loss from all causes between the spring of 1906 and the spring of 1907.

Grimm alfalfa entered the winter of 1905–6 with 4,117 hills, of which 718 emerged alive in the spring of 1906. Strains other than Grimm entered the winter of 1905–6 with 1,563 hills, of which only

39 hills emerged alive in the spring of 1906. This shows well the great rigor of the test. So far as the writer knows this is the severest loss which Grimm alfalfa ever suffered in any experiment.

The winter of 1905–6 was not an exceedingly severe one, though winter temperatures continued from November until nearly March 25. Temperatures below zero occurred in every month from November to March, inclusive. Nevertheless, the mean for these months as well as the mean for the strictly winter months was rather higher than normal. The lowest temperature experienced was −17° F., and there were twenty-five days with minima below zero. It is evident from this that some other cause than mere cold must be sought to explain the extensive winterkilling in all varieties.

The conditions as to precipitation that prevailed from the spring of 1905, when planting was done, until the spring of 1906, when the determinations of winterkilling were made, were as follows:

TABLE XII.—*Precipitation at Minneapolis, Minn., April, 1905, to March, 1906.*

Period.	Precipitation.	
	Form.	Inches.
April, 1905, to August, 1905	Rain	19.45
September, 1905, to November, 1905	do	8.44
December, 1905, to March, 1906	do	.58
November, 1905, to March, 1906	Snow	26.20
Total for the entire period		31.09

It is believed that two rather unusual factors were concerned in the losses observed. First, and perhaps the more important, was the large quantity of autumn rain, especially as almost 2½ inches fell during November, the greater part of it in the last decade of the month. Immediately following the last rain a minimum of −8° F. was recorded with no snow on the ground. December was practically a snowless month, only 0.4 of an inch falling. This condition, combined with a period of thawing during the latter part of February and another during the early part of March, probably explains the excessive winter losses in all varieties.

Observations that have been made indicate that losses in the case of excessive autumn moisture are due to three causes: (1) Failure of the plants to become dormant early enough; (2) actual rotting of the crowns if rainfall occurs after growth has stopped; (3) rupture or breaking of the roots, due to heaving of the ground.

With reference to alternate thawing and freezing, it may be said that the spring of 1902, when the 4 varieties shown in Table III suffered a comparatively moderate loss, was much more trying than a similar condition which prevailed in the spring of 1906.

In February, 1902, there were nine days with thawing temperatures, the maximum recorded being 54° F. Then followed a week of colder weather with a minimum of 10° F. Beginning on March 4 a period of twelve days of thawing weather with a maximum of 62° F. was followed immediately by two days with minima below zero.

In contrast, February, 1906, had seven days of thawing weather extending from the 18th to the 24th, the maximum recorded being 47° F. Then followed ten days of colder weather, three with slight thawing, the minimum recorded during the time being 6° F. In five days of thawing weather, March 5 to 9, the maximum recorded was 44° F. On the 11th a minimum of −6° F. occurred and cold weather continued until about the 24th, when the winter began to break up.

Snowfall during both February and March, 1906, was light. The minimum temperature for the winter (−17° F.) occurred February 10, when there was no snow on the ground and before the alternate thawing and freezing mentioned above. The most important features of the winter of 1905–6 as to temperatures are shown in the following tabulation:

TABLE XIII.—*Temperatures at Minneapolis, Minn., November, 1905, to March, 1906.*

Periods.	Mean.	Mean of the minima.	Lowest temperature.	Days with minima below zero.
	° *F.*	° *F.*	° *F.*	*Number.*
November, 1905	35.2	27.2	− 8	2
December, 1905	23.9	16.8	− 1	1
January, 1906	20.0	12.1	− 8	7
February, 1906	16.2	6.9	−17	11
March, 1906	22.4	15.3	− 6	4
For the 5 months	23.5	15.6	−17	25
For December, January, and February	20.0	11.93	−17	19

Experiments begun in the spring of 1906.—A collection of 15 strains of alfalfa was planted in hills in the spring of 1906; 4 Grimms, 3 Turkestans, 7 strains of ordinary alfalfa, and No. 16*b*, were included in the test. The seed used in the case of 13*b* to 16*b* (Table XIV) was grown from the 1905 plantings of these strains. Inasmuch as the plats from which the seed was taken were seeded in the spring of 1905, the seed used in 1906 must have been collected in the autumn from hills less than a year old. This gave a wide opportunity for crossing between hardy and nonhardy strains, without the intervention of a winter to eliminate the less hardy hybrids. The winterkilling that took place between the fall of 1906 and the spring of 1907 is shown in Table XIV.

TABLE XIV.—*Winterkilling of alfalfas in experiments begun in 1906 at St. Anthony Park, Minn.*

Minnesota No.	Source of seed.	Hills planted in spring of 1906.	Number of plants alive in—		Percentage of winter loss.
			Fall of 1906.	Spring of 1907.	
13*b*	Grimm, from 1905 planting (Table VIII, No. 13, and Table XI, No. 13*a*)	310	217	194	10.6
14*b*	Grimm, from 1905 planting (Table VIII, No. 14, and Table XI, No. 14*a*)	188	118	100	15.3
15*b*	Grimm, from 1905 planting (Table VIII, No. 15, and Table XI, No. 15*a*)	62	38	33	13.2
16*b*	Variety unknown; seed from 1905 planting (Table VIII, No. 16, and Table XI, No. 16*a*)	30	16	15	6.3
34	Montana, from original seed (Table XI)	256	193	28	85.5
36	Utah, from original seed (Table XI)	240	163	1	99.4
37	Colorado, from original seed (Table XI)	256	221	27	87.8
38	Nebraska, from original seed (Table XI)	240	167	11	93.4
1*b*	Home-grown Turkestan seed produced on station farm from S. P. I. No. 991 (Table XI, Nos. 1*a* and 2*b*)	240	150	63	58.0
2*b*	Home-grown Turkestan seed produced on station farm from S. P. I. No. 991 (Table VIII, No. 2, and Table XI, No. 2*a*)	256	233	133	42.9
3	Grown from commercial alfalfa, Minnesota No. 3 (Table XI, No. 3)	240	174	25	86.2
71	Ogden, Utah	256	242	28	88.4
72	Billings, Mont. (S. P. I. 12747)	240	188	9	95.3
73	Grimm, mixed seed from 1905 planting (Table XI)	256	201	128	36.3
75	Commercial Turkestan	1,488	1,226	1,116	8.9
	SUMMARY (AVERAGE LOSSES).				
13*b*, 14*b*, 15*b*, 73	Grimm, 4 strains	816	574	455	18.8
1*b*, 2*b*, 75	Turkestan, 3 strains	1,984	1,609	1,312	36.6
34–38, 3, 71, 72	Ordinary, 7 strains	1,728	1,348	129	90.8

The winter of 1906–7 was about normal in severity, as the following statement shows:

TABLE XV.—*Temperatures at Minneapolis, Minn., November, 1906, to March, 1907.*

Period.	Mean.	Mean of the minima.	Lowest temperature.	Days with minima below zero.
	° *F.*	° *F.*	° *F.*	*Number.*
November, 1906	33.6	27.7	10	0
December, 1906	20.1	12.7	−12	4
January, 1907	7.4	− .7	−18	16
February, 1907	17.5	8.3	−22	8
March, 1907	31.4	22.7	5	0
For the 5 months	22.0	14.14	−22	28
For December, January, and February	15.0	6.8	−22	28

The mean temperature for January was about 5 degrees below normal.

The following conditions as to precipitation prevailed from the spring of 1906 to the spring of 1907:

TABLE XVI.—*Precipitation at Minneapolis, Minn., April, 1906, to March, 1907.*

Period.	Precipitation.	
	Form.	Inches.
April to August, 1906	Rain	21.58
September to November, 1906	do	8.19
December, 1906, to March, 1907	do	.26
November, 1906, to March, 1907	Snow	28.70
Total for the entire period		32.90

A comparison of Tables XIII and XV shows that the winter of 1905–6 was milder than that of 1906–7; but in spite of this fact winterkilling was far more extensive. The mean temperature for the coldest month during the winter of 1905–6 (February) was 16.2° F. The mean for the coldest month in the winter of 1906–7 (January) was 7.4° F.

It seems likely that temperature and moisture conditions in November, 1906, have an important bearing on the reduced extent of winterkilling as shown in Table XIV as compared with Table XI. In November, 1905, the temperatures ranged rather high until within five days of the end of the month. This no doubt tended to keep the plants in a growing condition. Immediately following came three very cold days, the thermometer going to −2° F. on the 29th and to −8° F. on the 30th. In contrast November, 1906, grew cold gradually, this tending to produce dormancy without injury to the plants. The lowest temperature experienced during the month was 20° F., which occurred before the middle of the month. December, 1906, had 6½ inches of snow, while December, 1905, was practically snowless.

Experiments begun in the spring of 1907.—A new experiment, including 16 different samples, was begun in the spring of 1907. These samples included 7 of Grimm, 3 of ordinary alfalfa, and 6 selected strains. The selected strains included 3 selections made by Prof. W. A. Wheeler from Turkestan, S. P. I. No. 991 (South Dakota No. 164), another sample selected from the same S. P. I. number but distributed as South Dakota No. 240, and also a selection by Professor Wheeler from South Dakota No. 167, the so-called Baltic alfalfa.[a] The loss suffered by these strains during the winter of 1907–8 can not be told, as the hills were not counted in the autumn of 1907.

[a] For additional discussion of this strain, see Bulletin 185, Bureau of Plant Industry.

The temperature conditions that prevailed during the winter of 1907–8 are shown in the following tabulation:

TABLE XVII.—*Temperatures at Minneapolis, Minn., November, 1907, to March, 1908.*

Period.	Mean.	Mean of the minima.	Lowest temperature.	Days with minima below zero.
	° *F.*	° *F.*	° *F.*	*Number.*
November, 1907	34.6	27.8	11	0
December, 1907	25.0	17.1	− 2	1
January, 1908	19.8	9.8	−25	6
February, 1908	21.4	14.3	− 8	3
March, 1908	29.3	21.1	− 4	1
For the 5 months	26.0	18.0	−25	11
For December, January, and February	22.0	13.73	−25	10

The winter as a whole was several degrees warmer than normal, and the number of days with temperatures below zero decidedly less than the average. Conditions with respect to precipitation from April, 1907, to March, 1908, were as follows:

TABLE XVIII.—*Precipitation at Minneapolis, Minn., April, 1907, to March, 1908.*

Period.	Precipitation.	
	Form.	Inches.
April to August, 1907	Rain	15.89
September to November, 1907	...do	4.49
December, 1907, to March, 1908	...do	.35
November, 1907, to March, 1908	Snow	27.50
Total for the entire period		23.48

It may be stated that the autumn rainfall of 1907 was the lowest of any year during the period covered by these experiments, amounting to only 4.49 inches. All of the fall months had less than their normal amount of precipitation. The winter snowfall was normal.

In view of the character of the weather that prevailed, it is interesting to note that the average loss from all causes found by comparing the number of plants alive in the spring of 1908 with the number of hills planted in the spring of 1907 (not shown in Table XIX) was 6.6 per cent for the 7 Grimm samples and only 10.5 per cent for the 9 other samples.

The total loss, as determined by counting the plants alive in the spring of 1908 and in the spring of 1909, is shown in Table XIX.

TABLE XIX.—*Loss of alfalfas in experiments begun in 1907 at St. Anthony Park, Minn.*

Minnesota No.	Source of seed.	Number of plants alive in spring of—		Percentage of loss.[a]
		1908.	1909.	
4c	Grimm seed from 1905 planting (Table XI, No. 4*b*)	56	55	1.8
13c	Grimm seed from 1905 planting (Table XI, No. 13*a*)	96	92	4.2
14c	Grimm seed from 1905 planting (Table XI, No. 14*a*)	33	33	0.0
15c	Grimm seed from 1905 planting (Table XI, No. 15*a*)	70	62	11.4
81–95	Grimm; bulked seed selections by Wheeler in South Dakota from South Dakota No. 162	282	247	12.4
76	Commercial seed said to have been northern grown	50	8	84.0
77	Utah Dryland	51	14	72.6
78	Grimm, from Carver County, Minn., grown by Mr. Trieloff	250	250	0.0
79	South Dakota No. 167; Wheeler's selection from the so-called Baltic alfalfa	238	215	9.7
80	South Dakota No. 240; Wheeler's Highmore selections from Turkestan S. P. I. No. 991	251	243	3.2
96	South Dakota No. 164; selections by Wheeler made at Brookings and Highmore from Turkestan S. P. I. No. 991	24	24	0.0
97	South Dakota No. 164; selections by Wheeler made at Brookings and Highmore from Turkestan S. P. I. No. 991	16	14	12.5
98	South Dakota No. 164; selections by Wheeler made at Brookings and Highmore from Turkestan S. P. I. No. 991	23	22	4.4
99	Grimm seed produced in 1906 from 1905 planting	228	221	3.1
100	Seed from 1906 planting; probably Grimm	253	240	5.1
102	Billings, Mont., S. P. I. No. 12747	260	8	97.0
	SUMMARY (AVERAGE LOSSES).			
4c, 13c, 14c, 15c, 81–95, 78, 99	Grimm, 7 strains	1,015	960	4.7
79, 80, 96–98, 100	Selected by Wheeler, 6 strains	805	758	5.8
76, 77, 102	Ordinary, 3 strains	361	30	84.5

[a] Through an oversight counts of living plants were not made in the autumns of 1907 and 1908; hence, the percentages given in "Percentage of loss" column include losses due to all causes.

In this experiment were what may be truly termed the hardiest of all known cultivated alfalfas, including the Grimm, Wheeler's so-called Baltic alfalfa, and the hardy strains of acclimatized Turkestan alfalfa selected by Wheeler at Highmore and Brookings, S. Dak., presumably from Hansen's original importation, S. P. I. No. 991,[a] which came from the cotton-growing sections of Turkestan.

[a] There is little room for doubt that South Dakota No. 240 is the progeny of S. P. I. No. 991. With reference to South Dakota No. 164, its origin is not so well established, as the early records were somewhat faulty. This uncertainty should be borne in mind, but it does not necessarily interfere with the value of the results obtained.

The following statement concerning No. 991 occurs on page 81 of Inventory No. 1, Section of Seed and Plant Introduction:

991. MEDICAGO SATIVA. Alfalfa.

From Tashkend. Received through Prof. N. E. Hansen, June 4, 1898. (200 bushels.)

Variety "turkestanica." *This subspecies of alfalfa was obtained from eight different sources varying widely in climatic conditions.* It endures droughts which kill European alfalfa. Deemed very promising for trial in droughty reigons. See No. 469.

The italicized portion of this statement has been interpreted to mean that 991 is a blanket number for eight different lots of seed from various parts of Turkestan. A

Of the 1,268 Grimm plants (including No. 100, which is probably Grimm) alive in the spring of 1908, 1,200 came through alive in the spring of 1909. Of 552 plants of the hardy acclimatized strains[a]

careful study of the records clearly indicates that this interpretation, which has resulted in much uncertainty and confusion, is probably incorrect, and that the eight different sources alluded to in the note are represented by S. P. I. Nos. 469, 991, 999, 1101, 1150, 1151, 1159, and 1169. In the inventory the name "turkestanica," which has no botanical significance, is applied to each one of these eight numbers either directly or by reference.

From an examination of the records it is apparent furthermore that at least a part of the 200-bushel lot to which 991 was assigned was received as early as March, 1898. In a letter dated March 31, Prof. N. E. Hansen says: "By the way, the Turkestan alfalfa we received here came without any label as to locality. It is important that all these 10-pound lots that are sent out be labeled with the locality from which they came. The first lot as numbered are all from Samarkand." As bearing on the question as to whether or not 991 is a blanket number, Professor Hansen in a letter dated May 20, 1898, says:

"We would like very much to have a sample of each of the eight kinds of alfalfa sent for the small plats in the botanical and agricultural plats here—forage plant tests—[including] the Bokhara alfalfa just received [No. 679] and the Samarkand lot [no doubt a part of No. 991] received some time ago."

[a] The high degree of acclimatization to which alfalfa is susceptible appears to be well shown by experience with Turkestan No. 991 grown in comparison with Grimm. During the winter of 1903–4 (Table VIII), Minnesota No. 2, original Turkestan S. P. I. No. 991, lost 94.7 per cent; Minnesota No. 11, Turkestan, grown at Brookings, S. Dak., from S. P. I. No. 991, lost 84.8 per cent; Minnesota Nos. 13–15, Grimm, average of 3 pure strains, lost 15.6 per cent.

Minnesota No. 11 was produced in 1900 or 1901 at Brookings from the parent stock that later produced South Dakota No. 164 (Minnesota Nos. 96–98 given below). No. 164 was itself grown at Highmore, S. Dak., in 1906 from Brookings seed.

During the severe test of the winter of 1905–6 (Table XI), Minnesota No. 1*a*, Turkestan, grown in 1904 on the station farm from S. P. I. No. 991 seeded in 1899, lost 100 per cent; Minnesota No. 2*a*, Turkestan, grown on the station farm from S. P. I. No. 991 sent to Minnesota in 1900, lost 100 per cent; Grimm, average of 4 impure strains, lost 81.8 per cent.

By an impure strain is meant one which has been grown alongside of nonhardy strains in experiments, thus giving opportunity for deterioration through cross fertilization. A pure strain is one which has not been thus exposed.

After the winter of 1906–7 (Table XIV) opportunity again offered for comparing two different progenies of S. P. I. No. 991 with Grimm:

Minnesota No. 1*b*, Turkestan, produced on station farm from S. P. I. 991, lost 58 per cent; Minnesota No. 2*b*, Turkestan, produced on station farm from S. P. I. 991, lost 42.9 per cent; Grimm, average of 4 impure strains, lost 18.5 per cent.

After two seed generations in Minnesota the Turkestan strain appears to show definite acclimatizational effects.

In 1907 Grimm alfalfa was sown for comparison with the hardy strains developed by Professor Wheeler at Brookings and Highmore, from Turkestan S. P. I. No. 991. (Table XIX.) The winter of 1908–9 gave the following results:

Minnesota No. 80 (South Dakota 240), grown at Highmore, seven years after first planting, from S. P. I. 991, lost 3.2 per cent; Minnesota Nos. 96–98 (South Dakota 164),

alive in the spring of 1908, 518 were living in the spring of 1909, while 361 plants of ordinary alfalfa were reduced to 30 during the same period.

The winter of 1908–9 was practically normal as to temperature. The number of days with minima below zero was 22, the lowest minimum −26° F. The following tabulation is given to show the most salient features as to temperature, for use in connection with Tables XIX and XXI:

TABLE XX.—*Temperatures at Minneapolis, Minn., November, 1908, to March, 1909.*

Period.	Mean.	Mean of the minima.	Lowest temperature.	Days with minima below 0° F.
	° *F.*	° *F.*	° *F.*	*Number.*
November, 1908	36.2	28.4	5	0
December, 1908	21.0	13.0	− 8	4
January, 1909	14.5	6.5	−26	12
February, 1909	18.0	10.1	−15	6
March, 1909	29.2	22.9	2	0
For the 5 months	23.8	16.18	−26	22
For December, January, and February	17.8	9.86	−26	22

Experiments begun in the spring of 1908.—In the spring of 1908 nearly 5,000 hills of Grimm alfalfa, including 4 different numbers and 122 plants of No. 16*c*, were set out. The endurance that they showed during the winter of 1908–9 (temperatures in Table XX) is shown in Table XXI.

grown at Highmore in 1906 from seed produced at Brookings from same stock as Minnesota No. 11 (above), lost 5.6 per cent; Grimm, 6 impure and 1 pure strain, on an average lost 4.7 per cent.

South Dakota 240 (Minnesota No. 80), acclimatized Turkestan, was grown from seed originally imported from Tashkend, Turkestan, by Prof. N. E. Hansen in 1898 under S. P. I. No. 991. It was grown at Highmore from 1899 until 1906, when the seed used in the above experiment was harvested.

South Dakota 164 (Minnesota Nos. 96–98), acclimatized Turkestan, is supposed to be from seed of the same importation as No. 240 but grown at Brookings from 1898 to 1904. Brookings seed was taken to Highmore and grown there from 1905 to 1906, when the seed used in the above experiment was produced.

Results similar to the above were obtained in the Dickinson, N. Dak., experiments briefly described later: S. P. I. No. 991, part of original importation, lost 91 per cent; P. L. H. No. 3252 (South Dakota 240), produced in 1904 after five years of unconscious selection at Highmore, from S. P. I. 991, lost 9 per cent; S. P. I. No. 21938 and P. L. H. No. 3235, Grimm, produced in Minnesota and North Dakota, respectively, lost 4.9 per cent.

TABLE XXI.—*Winterkilling of alfalfas in experiments begun in 1908 at St. Anthony Park, Minn.*

Minnesota No.	Source of seed.	Hills planted in spring of 1908.	Number of plants alive in—		Percentage of winter loss.
			Fall of 1908.	Spring of 1909.	
4*d*	Grimm seed from 1905 planting (Table XI, No. 4*b*).....	281	279	263	5.7
13*d*	Grimm seed from 1905 planting (Table XI, No. 13*a*)...	2,930	2,768	2,729	1.4
14*d*	Grimm seed from 1906 planting (Table XIV, No. 14*b*).	1,280	1,215	1,192	1.9
15*d*	Grimm seed from 1905 planting (Table XI, No. 15*a*)...	219	207	207	0.0
16*c*	Original source unknown; present seed from 1905 and 1906 plantings (Table XI, No. 16*a*; and Table XIV, No. 16*b*).....	122	122	121	.8

The average loss of the 4 Grimm samples was 2 per cent. The behavior of ordinary alfalfa, the average loss of which was 84.5 per cent under the same conditions, may be seen by consulting Table XIX, Nos. 76, 77, and 102. The appearance of No. 102—common alfalfa from Montana—as compared with Grimm alfalfa, is shown in Plate I, figure 2.

Conditions with respect to precipitation from April, 1908, to March, 1909, were as follows:

TABLE XXII.—*Precipitation at Minneapolis, Minn., April, 1908, to March, 1909.*

Period.	Precipitation.	
	Form.	Inches.
April to August, 1908.....	Rain....	20.95
September to November, 1908.....	...do....	6.77
December, 1908, to March, 1909.....	...do....	.29
November, 1908, to March, 1909.....	Snow...	33.55
Total for the entire period.....		33.37

Autumn moisture conditions were rather less trying than the average; winter temperatures were nearly normal, and the snowfall the greatest that occurred between 1901 and 1908. The Grimm, as in each other experiment discussed, showed itself to be inferior to none in hardiness.

By way of summarizing the results of the Minnesota experiments, it may be said that they proved without doubt the great hardiness of Grimm alfalfa. They also leave no doubt as to the nonadaptability to Minnesota conditions of all of the strains of common alfalfa that have been tried. They indicate very strongly the great importance of so locating seed plats of Grimm and other hardy strains that contamination by crossing with less hardy strains can not take place. In connection with the studies of temperature and precipitation these experiments point out some of the climatological factors of

importance that control the cold resistance of alfalfa. In combination with low temperatures, snow covering, autumn moisture, and alternate thawing and freezing appeared to be the chief factors that determine the amount of winterkilling in alfalfa.

EXPERIMENTS AT FARGO, N. DAK.

The North Dakota Agricultural Experiment Station began experiments in 1902, under the direction of Prof. J. H. Shepperd, with Grimm alfalfa seed furnished by the Minnesota experiment station. The following summary of facts is gleaned from the published station reports (North Dakota Bulletins Nos. 65 and 76):

Seed of a strain of alfalfa, named Grimm by the Minnesota experiment station, was seeded upon a plat of land last spring. The growth of the plants came on more quickly and they seemed somewhat more sturdy than those from the Turkestan seed.

Report for 1903.—The results of the alfalfa yields for 1903 were accidentally lost, but the following statement taken from the annual report upon the field trial work that year indicates that the yield of hay was probably a little over 2 tons per acre. "The Grimm strain of alfalfa, which was sown in 1902 upon ground adjoining the Turkestan trial, has proved more thrifty and vigorous than the Turkestan strain. The Grimm alfalfa filled its seed pods with plump, ripe seeds somewhat better than the Turkestan variety, while the plants descended from Utah seed yielded an abundance of shriveled and emaciated seed which had little growing strength."

Results in 1904.—The Grimm alfalfa plat showed a thick, strong stand in 1904, although it did not grow as high as the Turkestan variety. On June 21, the date of cutting the first crop for hay, it measured 24 inches high. The yield of hay from the first cutting was 3,720 pounds per acre. The second growth was left to ripen and was cut for seed with a binder about 10 days after it had been killed by frost. This second growth did not mature sufficiently, and the trial indicates that the first crop would have made a better yield of seed than was secured from the second growth. The yield of seed from this second growth was only 50 pounds per acre, about half of which is too immature to grow.

In 1906 the Grimm alfalfa was left for seed. The stand was nearly perfect. An exceptionally heavy growth was produced, giving a yield estimated at nearly 3 tons per acre.

A small plat of Grimm alfalfa growing upon an adjoining piece of land was used to propagate seed so regularly that hay yields could not be taken each season, but field observations, together with the comparison made in the season of 1904, leave no doubt that the yields of hay had they been harvested would have been greater upon the Grimm than they were upon the Turkestan plat. These plats have not winterkilled, but standing water has killed out patches of the plants.

It is essential that alfalfa land be drained so as to be free from standing water, even for short periods, for such covering in the spring season seems fatal to the crop.

It will be seen from these statements that Grimm alfalfa has proved one of the most satisfactory that the North Dakota station has tested. Both Professor Shepperd and Asst. Prof. O. O. Churchill have stated in correspondence and conversation that Grimm alfalfa has proved entirely satisfactory for their section.

Seed produced on the Fargo plats in the season of 1904 was used in experiments at Dickinson, N. Dak., to be discussed later, begun in

the springs of 1905, 1906, and 1908. Temperatures ranging very close to −40° F. were endured in the interim between the spring of 1902, when the seeding took place, and the fall of 1904, when the seed was harvested. Autumn moisture conditions were such that selection toward resistance in this respect also took place.

A sample of alfalfa seed purchased under the name of Grimm alfalfa was sown in test plats during the summer of 1909. After the physiologically mild winter of 1909–10, the great majority of the plants in one of the tests had been killed. In 1910 statistical studies of diversity in flower color on this sample showed a variegation of only 4.7 per cent, while the average for two strains positively known to be Grimm was 44.4 per cent. The high percentage of winterkilling and the comparative absence of variegation leave no doubt that in this case the sample was not Grimm alfalfa and that the grower who produced the seed was in error in pronouncing it Grimm and in selling it as such. Cases of this kind should serve as a warning to both buyer and seller of Grimm seed. This alfalfa is so distinct that the sale of seed that is not true to name, whether intentional or unintentional, will soon be detected.

EXPERIMENTS AT TAPPEN, N. DAK.

In the spring of 1905 the writer began an experiment to test the hardiness of 16 strains of alfalfa 6 miles south of Tappen, N. Dak. The work has been carried on in cooperation with Mr. W. H. Niles, who is, so far as we know, the largest alfalfa grower in North Dakota, having considerably over a hundred acres on his ranch, which he cut three times during the season of 1909. In this experiment, which was seeded in May, 1905, the 16 strains were sown on half-acre plats. The following table shows the estimated percentage of stand in September, 1909, at the close of the fifth season:

TABLE XXIII.—*Number, source, and estimated percentage of stand, September, 1909, on alfalfa plats near Tappen, N. Dak.*

Plat No.	S. P. I. No.	Source of seed.	Percentage of stand.
1	12816	Chinook, Mont.	90
2	12747	Billings, Mont.	90
3	12820	Clearwater, Nebr.	85
4	12671	Lawrence, Kans.	85
5	12398	Fort Collins, Colo.	60
6	12409	Spanish Fork, Utah (dry land)	30
7	12784	Emery, Utah (irrigated)	10
8	12801	Texas (Panhandle)	5
9	12702	Sherman, Tex.	5
10	12748	Hesse, Germany (Eifeler lucern)	5
11	12695	Poitou, France	5
12	11275	Europe, commercial seed	5
13	12991	Minnesota (Grimm)	90
14	13291	Fayetteville, N. Y.	30
15	13857	Simbirsk, Russia	60
16	13858	Kharkof, Russia	60

Temperatures lower than −30° F. occur practically every winter at Tappen. Nevertheless it will be noted that in the present experiments northern and southern Montana alfalfa have given as satisfactory results as Grimm. The same may be said of commercial Turkestan alfalfa, which Mr. Niles grows rather extensively. The explanation of this fact may be found in the nature of the soil, in soil-moisture conditions, and in a lack of autumn rainfall. The soil of the experimental field is an open sandy loam. The water table reaches to within 8 or 10 feet of the surface, so that the plats are not wholly dependent on rainfall for their moisture. The autumns are practically always dry, and the open nature of the soil readily takes care of any slight excess that can not be removed through the transpiration of the plants.

Many of the strains included in this experiment were duplicated in the experiments at Dickinson, N. Dak., and there is a general agreement in behavior as to cold resistance at the two places. The behavior of the Utah, Texas, and foreign strains shows how utterly unadapted these are for cultivation in cold climates.

The behavior of the Eifeler lucern from Germany is of special interest, as this sample came from the Grand Duchy of Hesse, in Germany, which is near the Grand Duchy of Baden, whence Grimm brought his original seed. The Eifeler lucern is practically identical in its botanical characteristics with Grimm alfalfa. Its physiological behavior, as may be seen from the endurance test at Tappen, is altogether different. The commercial European seed, No. 11275, also has the same botanical characteristics as Grimm alfalfa and Eifeler lucern, including greater diversity both in variegation of flower color and habit of growth than our ordinary Utah and Montana kinds. The German strain and also the commercial plat had only about 5 per cent of a stand remaining. All of these plats were cut for seed in August, 1909. The best, including the Grimm and Montana strains, yielded about 2½ bushels per acre; the Utah irrigated strain, with 10 per cent of a stand, yielded only about 10 pounds of seed; the plats with less than 10 per cent of a stand were not thrashed. The work at Tappen indicates that in the drier portions of North Dakota farmers who desire to grow alfalfa, and who can not obtain Grimm seed, should use either Montana or Nebraska strains.

It must be borne in mind that the peculiar sources of moisture supply at Tappen preclude a wide application of the results of this experiment. An experiment similar to this was begun at Minot, N. Dak., at the same time, but on account of the shortage of Grimm seed this strain was not included in the test. Minot is farther north and, on the whole, has colder winters. In spite of the fact that in order to thicken up the stand all the plants were permitted to go to

seed in the summer of 1907, the seed being harrowed in, none of the plats have a stand remaining that would warrant continuing them.

EXPERIMENTS AT DICKINSON, N. DAK.[a]

Perhaps the most comprehensive and careful comparison of Grimm alfalfa with other kinds has been made at the Dickinson branch of the North Dakota experiment station. The first plat was sown in 1905, and part of it still remains. In 1906 duplicate plats were seeded in comparison with 21 other kinds. In the spring of 1908 five strains of Grimm having different histories were sown in various experiments. Each strain gave a good account of itself, especially in the hill and drill-row experiments, which furnish the severest possible test of hardiness under the conditions present. In this experiment 68 strains obtained from the most important alfalfa-growing regions of the world were given identical treatment under conditions of great uniformity.

The winter of 1908–9 was normal as a whole, with a mean temperature of 13.8° F. During January there was one period of two weeks when the highest minimum recorded was −3° F. and the lowest −31° F. During ten days of this time the maximum rose above zero only once. The preceding autumn had been moist and the snowfall was below normal.

Grouped in accordance with their immediate geographical origin the average losses in the various strains were as shown in Table XXIV. As Grimm alfalfa originally came from Europe, the average losses of 14 strains, the sources of which were known with reasonable definiteness, out of the 15 European strains are of special interest, and these are given more in detail in the table.

TABLE XXIV.—*Winterkilling of 68 strains of alfalfa in experiments at Dickinson, N. Dak., winter of 1908–9.*

Summarized record of all strains.			Separate record of 14 out of 15 European strains.		
Number of strains tested.	Source of seed.	Percentage of winter loss.	Number of strains tested.	Source of seed.	Percentage of winter loss.
4	Arabia	100	2	Russia	84
5	South America	100	5	Germany	83
3	Africa	93	5	France	90
15	Europe	87	1	Italy	99
26	North America	70	1	Spain	100
15	Asia	65			

Three of the strains attributed to Germany and 2 of the French samples were the so-called sand lucern, some lots of which have been

[a] Only a bare summary of the Dickinson experiments is presented here, as they have been reported upon in detail elsewhere. See Bulletin 185, Bureau of Plant Industry.

found to be very similar botanically to Grimm. The average loss of these 5 strains was 79 per cent, the range being from 63 to 90 per cent.

In the experiment as a whole 12 of the 68 strains winterkilled 100 per cent; 16 from 90 per cent to 99 per cent; 42 more than 80 per cent; 58 over 50 per cent; and only 10 less than 50 per cent. Of the 10 strains which lost less than half, 6 winterkilled more than 33⅓ per cent, leaving only 4 of the 68 strains that lost less than one-third. Of the 3 kinds that lost less than 10 per cent, 2 were Grimms. Their average loss was under 5 per cent, while the average for the whole experiment was 78 per cent.

EXPERIMENTS AT HIGHMORE, S. DAK.

The South Dakota Agricultural Experiment Station began to experiment with Grimm alfalfa in 1902, but the seed used came from a commercial source and appears not to have been true to name. At any rate, in careful experiments in hills at the Minnesota experiment station in which true Grimm was compared with this so-called Grimm the following differences in winterkilling were apparent:

TABLE XXV.—*Winterkilling of alfalfas in experiments at Highmore, S. Dak.*

Variety.	Number of plants alive in the—		Percentage of winter loss.
	Fall.	Spring.	
True Grimm	217	194	11
So-called Grimm	174	25	86

In 1905 true Grimm seed was obtained and planted. According to Prof. W. A. Wheeler [a] this strain did not, during the winter of 1905–6, lose a single plant either in selection rows or plats under varying conditions at Highmore and Brookings. Wheeler's observations, as given in the bulletin referred to are as follows:

No. 162.—The seed of this number is, according to records, from the same original source as No. 67, the so-called Grimm alfalfa referred to above, but in all tests made during the last two years the results obtained from these two numbers are at variance. No. 162 is very much hardier than No. 67; in fact it seems to be perfectly hardy, as not a plant was known to winterkill in 1905–6, either in selection rows or in plats under varying conditions at Brookings or Highmore. The selection-row test for hardiness is the most severe test that can be given, as the plants, when grown in these rows, have 3 feet of bare ground on each side of them. In quality of forage and in the vigor of growth in early spring, this number is second to none listed here. In seed production it is one of the best but has not been compared a sufficient length of time with No. 167 to determine which produces the greater amount and better quality of seed.

[a] Wheeler, W. A., and Balz, S., Forage Plants at the Highmore Substation, 1906, Bulletin 101, South Dakota Agricultural Experiment Station, 1907, p. 136.

The Grimm alfalfa, which is the original No. 162, has been grown near Excelsior, Minn., for about forty years and appears to be thoroughly acclimated to Minnesota conditions as far as forage value is concerned. In Minnesota, however, it fails, under ordinary conditions, to produce seed readily. The Grimm alfalfa has been tested in many parts of the United States as well as Canada and has shown itself to be one of the hardiest, if not the hardiest alfalfa under trial either by the State stations or by the United States Department of Agriculture. A plat of this variety was seen by the writer at Indian Head, Saskatchewan, in the summer of 1906, which was being grown in comparison with several others. [For details of this experiment, see pp. 44–47.] It had passed through two winters without winterkilling in the least, and was making a very fine growth, while others under trial had, to a large extent, winterkilled. South Dakota No. 162, which is the Grimm acclimated to South Dakota conditions, ranks with the two or three best alfalfas for South Dakota.

Temperature and autumn moisture conditions at Highmore during the progress of Wheeler's experiments were such as to give a reliable test of hardiness, especially as the Grimm and many of the strains with which it was compared were grown in hills and nursery rows. Winters that do not register temperatures 20 or more degrees below zero are rare at this point, the lowest temperature thus far recorded being about −40° F. (−40° C.).

EXPERIMENTS AT FAYETTEVILLE, N. Y.

In the spring of 1905 an endurance test of 14 regional strains of alfalfa was seeded in cooperation with Mr. F. E. Dawley, on his farm near Fayetteville, N. Y. The series of alfalfas used in this endurance test is similar to that described above, at Tappen, N. Dak. In August, 1909, Mr. T. R. Robinson, Assistant Physiologist in the Office of Soil-Bacteriology and Water-Purification Investigations, kindly visited these plats, and in company with Mr. Dawley, made notes in regard to their present condition. Only 4 of the 14 were maintaining a good stand and on August 24 were ready for the third cutting. These, in order of their excellence, were as follows:

S. P. I. No. 12991, Grimm alfalfa from Minnesota.
S. P. I. No. 11211, Turkestan alfalfa from Samarkand.
S. P. I. No. 12409, Dry-land alfalfa from Emery, Utah.
S. P. I. No. 11275, Commercial alfalfa from Europe.

The following concerning the remaining strains is quoted from Mr. Robinson's report:

Poitou, France, 12695, and Italian 12696 may be classed as entire failures; in fact they had been partially plowed up. Colorado 12398, Utah irrigated 12785, and Texas Panhandle 12801 are only fair. Sherman (Tex.) 12702 was poor. Chinook (Mont.) 12747, Nebraska 12820, and Kansas 12671 are dying out in spots, leaving some bunches still growing well, but not a good stand.

In 1906 and 1907 the hay product of these plats was weighed. In 1906 three crops were cut; in 1907, on account of drought, only two. In both years Grimm alfalfa outyielded all other kinds; in two or

three cases only slightly, in others giving more than twice the yield. For instance, comparing Grimm with the Turkestan strain (No. 11211), which Mr. Robinson found was maintaining almost as good a stand, Grimm yielded in 1906 a total crop of 7,450 pounds as against 3,340 for the Turkestan. In 1907 Grimm yielded in two cuttings 5,440 pounds as compared with 2,300 pounds for the Turkestan. Compared with the Utah nonirrigated seed No. 12409 (which in the autumn of 1909 was still one of the four best plats), Grimm in 1906 yielded 5,440 pounds; Utah, 4,820. Compared with Italian No. 12696 (which has a very similar varigation in flower color), Grimm in 1906 yielded 7,450 pounds as against 3,990 for the Italian; in 1907 the yields were 5,440 pounds for Grimm and 2,810 pounds for the Italian. These figures indicate that the Grimm can be depended upon not only on account of its superior hardiness, but also because of its hay-yielding capacity.[a]

TABLE XXVI.—*Monthly minimum temperatures, total snowfall, and rainfall during preceding autumns at Fayetteville, N. Y., 1905–1909.*

Season.	Monthly minimum temperatures.				Precipitation.	
	December.	January.	February.	March.	Snow.	Rain during preceding autumn.
	°F.	°F.	°F.	°F.	*Inches.*	*Inches.*
Winter of 1905–6	− 2	−20	−22	−4	45	7.95
Winter of 1906–7	−13	−20	−13	−4	37	10.67
Winter of 1907–8	0	−12	−20	8	52	10.10
Winter of 1908–9	4	−13	− 8	10	67	4.14

While the winter temperatures at Fayetteville are moderately low, the snowfall is so heavy that their injurious effects are considerably reduced. On the other hand, excessive autumn moisture, which leaves the soil in a saturated condition, constitutes an unfavorable factor which tends to equalize the severity of conditions in this area, as compared with the cold portions of the Great Plains, where very low temperatures, preceded by rather dry autumns, are the rule.

[a] It should be stated that while Turkestan alfalfa frequently shows a satisfactory degree of hardiness it does not, as a rule, make the growth nor give the yield of either hay or seed that Grimm does. This has been pointed out as regards hay production in Professor Shepperd's experiments at Fargo and was again evident in the present experiment at Fayetteville. It seems likely that this is due to the fact that the Turkestan strains are accustomed to much higher summer temperatures than prevail in our northern country. Wheeler's experiments in South Dakota tend to indicate that as acclimatization progresses these faults in the Turkestan become less and less apparent in successive seed generations. In the case of both the Tappen and Fayetteville experiments it was the intention to subject the varieties to such conditions as they would be called upon to endure in actual farming practice.

EXPERIMENTS AT BOZEMAN, MONT.

The Montana Agricultural Experiment Station at Bozeman has also tested Grimm alfalfa in comparison with a number of other kinds, including seed from various parts of Montana, and also a collection of about 10 strains from various parts of Turkestan.[a] The results of these experiments have not yet been published. In a letter under date of October 8, 1909, Prof. Alfred Atkinson, agronomist of the Montana station, makes the following statement:

> Our experiments with Grimm alfalfa indicated that it is decidedly the best for many sections of the State. Two years ago a large percentage of the plants in the different variety plats were winterkilled, but the Grimm alfalfa showed no injury. * * * I certainly consider it a plant worth putting forward, and hope to be able to get it out to Montana farmers in two or three years. * * * I may say that the seed produced in northern Montana is said to be very superior. In our tests at Bozeman this did not show up quite so well as the Grimm alfalfa. Montana-grown seed of the common strain, however, shows itself to be much hardier than any of the strains of Turkestan which we included in the tests.

Although the data upon which Professor Atkinson bases his conclusions have not yet been published, it is evident from this summary that they coincide with the results at St. Anthony Park, Minn., Dickinson, N. Dak., and other places where Grimm alfalfa has been tested in comparison with other kinds.

EXPERIMENTS AT INDIAN HEAD, SASKATCHEWAN, CANADA.

During the winter of 1904–5 arrangements were made with Dr. William Saunders, director of experiment stations for the Dominion of Canada, for a cooperative experiment with a number of varieties of alfalfa on the experimental farm for Saskatchewan at Indian Head. This work has been carried out under the immediate supervision of Mr. Angus Mackay, superintendent, and the data given below are based upon the reports which Mr. Mackay has furnished from year to year. The alfalfas in the series shown in Table XXVII were sown in May, 1905:

TABLE XXVII.—*Condition of alfalfas in the spring of 1906 in experiments begun in 1905 at Indian Head, Saskatchewan, Canada.*

S. P. I. No.	Source of seed.	Condition in the spring of 1906.
12747	Billings, Mont. (irrigated)	Almost all killed; plat plowed up.
12409	Diamond Fork, Utah (nonirrigated)	Do.
9303	Peru, South America (irrigated)	All dead; plat plowed up.
11211	Samarkand, Turkestan	About 60 per cent of the stand remaining.
11275	First quality commercial (variegated alfalfa from Europe).	Almost all killed; plat plowed up.
12991	Carver County, Minn. (Grimm)	About 95 per cent of the stand remaining.
13237	Chinook, Mont. (irrigated)	About 20 per cent of the stand remaining; plat plowed up.
13291	Fayetteville, N. Y.	About 50 per cent of the stand remaining.
13259	Milburn, Nebr.	Do.

[a] Among the strains tested were S. P. I. Nos. 9359, 9450, 9451, 9452, 9453, 9454, 9455, 9816, and 11211.

All of these plats went into the winter of 1905–6 with a fairly good stand, as the summer of 1905 had been an exceedingly favorable one for alfalfa. Nineteen inches of rain fell during the growing season. It seems likely that when winter arrived a saturation of the soil existed that was decidedly injurious to all strains, except the Grimm, which is thoroughly acclimatized to a moist condition of the soil, accompanied by exceedingly low temperatures.

The Grimm and Samarkand strains made the quickest recovery after cutting in 1905, and the Grimm was the earliest to begin growth in the spring of 1906. Only 4 of the 9 kinds named above kept a sufficient stand to warrant continuing the plats after 1906. The hay yields for these three years are shown in Table XXVIII:

TABLE XXVIII.—*Calculated yield in pounds per acre of alfalfa varieties at Indian Head, Saskatchewan, Canada, 1904–1909.*

Cutting.	Common.	Turkestan.	Minnesota (Grimm, S. P. I. No. 12991).	New York (S. P. I. No. 13291).	Turkestan (S. P. I. No. 11211).	Nebraska (S. P. I. No. 13259).
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1904	(a)	(a)				
1905 First cutting	4,422	5,480				
1905 Second cutting	2,900	3,360	(a)	(a)	(a)	(a)
Total	7,322	8,840				
1906 First cutting	960	1,800	4,181	(b)	(b)	(b)
1906 Second cutting	1,020	1,940	2,931	2,500	2,560	2,450
Total	1,980	3,740	7,112			
1907 First cutting			(c)	(d)	(d)	(d)
1907 Second cutting				3,818	3,909	3,038
1908 First cutting			6,136	6,704	5,636	4,367
1908 Second cutting			2,955	3,227	3,026	2,358
Total			9.091	9,931	8,662	6,725
1909 First cutting			5,318	4,000	3,910	3,090
1909 Second cutting			(e)	(e)	(e)	(e)
Grand total	9,302	12,580	21,521	20,249	19,041	15,303

a Clipped but not weighed first year.
b Cut for weeds.
c Left for seed.
d Cut only once.
e Put in silo; not weighed.

It will be noted from the table that in 1906 the Grimm yielded two good cuttings, while the other less hardy strains from New York, Turkestan, and Nebraska were cut for hay but once. Common alfalfa, which had yielded 7,322 pounds in 1905, and Turkestan alfalfa, which had yielded 8,840 pounds in the same year, were so seriously injured by the winter of 1905–6 that their yields were cut down to 1,980 and 3,740 pounds, respectively. This is the same winter that injured so badly the alfalfa in the experiments at St. Anthony Park, Minn., discussed above. It also proved very injurious to Wheeler's experiments at Highmore and Brookings,

S. Dak., and is the only winter of recent years that has seriously injured stands of Grimm alfalfa in Carver County, Minn. In another publication [a] the injurious effects of this winter have been attributed to an excess of moisture in the soil due to heavy autumn precipitation in 1905.

In 1907 the Grimm alfalfa plat was left to go to seed and was not cut until September 23. The New York, Turkestan, and Nebraska strains were cut but once, on July 22, the subsequent growth being left for winter protection. By 1908 the thinned-out stand on the three last-named plats had considerably improved through the greater development of the plants due to the added space available for each individual. In this year two cuttings were made. In 1909 two cuttings were made, but only the first was weighed, the second being put in the silo without weighing.

In the five years for which data as to yields are available the grand total yield of the Grimm for three years, 21,521 pounds, exceeds that of the next best plat, that from New York, which yielded 20,249 pounds in four years.

In his letter transmitting report for 1906 Mr. Mackay made the following statement:

> When I reported to you in April last spring most of the plats had just started, but by May 15 all were dead excepting those mentioned [Table XXVII] as giving some returns. One variety only—Minnesota Grimm—was not injured by the frosts and gave two cuttings.

Again, in sending in his report for 1908, special comment is made on the Grimm:

> From the first the Grimm alfalfa has never been winter or spring killed in the least, and on this account I consider it the most valuable strain for this country. Last year the New York, Samarkand, and Nebraska gave good returns, but in the previous year all were more or less injured by spring frosts and thaws.
>
> I may say that the spring of 1908 was an exceptionally good one for clovers, * * * and all strains whether of alfalfa or of red clover stood perfectly; the season being favorable in regard to moisture and heat, good yields were the result in all cases.

Again, in transmitting his report for 1909, Mr. Mackay made the following statement:

> I am very glad to report favorably on the Grimm alfalfa obtained from your department in 1905; in no year has it been injured or killed by spring frosts, and I have great hopes that in the future it will not fail in this respect.
>
> Next spring it is the intention to sow 25 to 30 acres with alfalfa and if the seed can be obtained the Grimm will be used.

The results at Indian Head add confirmation to those already reported on in experiments at other places. There seems no room for

[a] Bulletin 185, Bureau of Plant Industry, p. 62.

reasonable doubt as to the great hardiness of the Grimm alfalfa for our northern country and Canada and its great consequent potential value.

EXPERIENCES OF FARMERS.

The results obtained by investigators, as detailed above, have been borne out by experiences of many practical farmers, especially in the Northwest, but also in other parts of the North.

In the spring of 1901 Mr. Clarence Wedge, of Albert Lea, Minn., seeded both Grimm and Turkestan alfalfas. The Grimm was sown on poorly prepared soil which had been spring plowed. The Turkestan seed fared better; it was sown on fall-plowed land that had been in corn and was thoroughly prepared. Despite this advantage the Turkestan field lasted only about two years, while the Grimm lasted six years. It still had a good stand in the autumn of 1905, but by the spring of 1907 was so badly injured that it had to be plowed up. The disastrous effects to alfalfa in Minnesota of the fall and winter of 1905–6 have already been discussed in connection with the work at St. Anthony Park (pp. 27-29).

Mr. A. B. Lyman's experiences with commercial alfalfa seed, about 1891 to 1892, have already been touched upon. In 1894 he began growing Grimm alfalfa and since that time Grimm alfalfa has been grown continuously on his farm; once as many as 100 of his 250 acres were devoted to it.

A number of Mr. Lyman's neighbors have tested commercial lots of seed, both of domestic and foreign origin. He has had uniform success; they, uniform failure. In the spring of 1906 Mr. Matt Bongard, a near neighbor, seeded a field with a grass mixture, one-third of which was first-quality commercial alfalfa seed that came from Europe. According to the best information obtainable an excellent stand of plants resulted, in which the alfalfa largely preponderated, though considerably less than the customary amount of seed was applied. In September, 1909, after three winters, less than 3 per cent of a stand remained on this field. Such experience is not unusual, as even more extreme cases have come under the writer's observation when Minnesota farmers have attempted to grow nonhardy strains of alfalfa.

Not more than 1,000 feet away from Mr. Bongard's field Mr. August Kelm has a field of Grimm alfalfa shown in Plate II, figure 1. This field is 11 or 12 years old, and retains about 80 per cent of the stand, though the original seeding in this case also is said to have been thin. Even the 25-year-old field of Grimm shown in Plate I, figure 1, has four or five times as many plants remaining per unit of area as the 3-year-old field of newly imported alfalfa on the Bongard farm.

Mr. Alfred Maxwell, of Excelsior, Minn., has a small field of Grimm alfalfa that is over 20 years old, and still has a good stand. On another part of his farm he has a field about 7 years old sown with commercial seed. Its stand is so thin that it should be plowed up. Near the field of commercial alfalfa Mr. Maxwell has a hog pasture that was seeded to Grimm about the same time the commercial lot was sown. Despite the harsh treatment due to pasturing this Grimm field retains fully 60 to 70 per cent of the stand.

Mr. George Schoolmeester, another Carver County farmer, used some commercial seed about six years ago to finish sowing one of his Grimm fields. In two years the commercial strain had almost totally killed out. The Grimm still retains a full stand, although it was seeded very thinly.

Mr. Isaac Lincoln, of Brown County, S. Dak., has 7 acres of Grimm alfalfa that kept a perfect stand after the winter of 1908–9, when other strains winterkilled extensively in his section. In the spring of 1909 he made a new seeding of Grimm of equal area.

In the spring of 1904 Endsley Bros., of Milford, Ill., seeded 100 pounds of Grimm alfalfa. At the same time a near neighbor seeded ordinary Kansas alfalfa on the same type of land. In three years the ordinary alfalfa had all killed out, while the Grimm, according to statement of Mr. P. M. Endsley of Excelsior, Minn., still retained a perfect stand in the fall of 1909. In the spring of 1908 another seeding of 220 pounds of Grimm alfalfa was made, and although that season was very unfavorable, the result was a good stand that successfully endured the winter of 1908–9.

Scores of other cases could be cited in which Grimm alfalfa has made good in the experience of practical farmers. The writer has the names and addresses of fully 500 farmers who are now growing or have grown this variety; some of them on small plats only, others on a field scale.

OTHER CHARACTERISTICS OF GRIMM ALFALFA.

The behavior of Grimm alfalfa in respect to other characters than hardiness remains to be discussed.

FORAGE-PRODUCING CAPACITY.

In the area for which it is recommended, other things being equal, Grimm gives more and fuller crops, and hence larger yields than any other kind. This no doubt is largely due to its hardiness, by virtue of which it maintains more perfect stands over a longer period of time than other sorts.

In Carver County three good crops of hay are generally harvested. The dates of cutting vary greatly with different seasons. The earliest date for harvesting the first crop of which the writer knows is May 28; the latest date, June 15. The second crop is usually cut between July 10 and 20; the third between August 25 and September 10.

There is usually a generous aftermath in the way of a fourth growth. The German farmers generally pasture this with cattle or horses, rarely with sheep. The ability of the Grimm to endure autumn pasturing is of great advantage to the farmer and adds much to the money value of the variety. Unacclimatized strains can not bear this hard usage.

The writer is familiar with a field of Grimm now 9 or 10 years old which soon after being seeded was used as pasture for a large number of horses from early autumn until late spring. The ground in spring appeared to be bare. Nevertheless, a profitable stand remains to this day on this field, which has been repeatedly pastured in autumn.

Mr. Lyman finds hog raising very profitable in connection with alfalfa growing, and frequently cuts his fourth growth for feeding hogs. No observable injury to his stands has resulted from this practice. In the Northwest, when commercial strains of alfalfa are pastured or given late cuttings they rarely last as long as three years.

GENERAL BEHAVIOR AND TEMPERATURE RELATIONS.

As a general thing nonhardy strains of alfalfa pass through their first winter without great loss. This is especially true when seeded with grain. The explanation is not difficult to find. The grain stubble serves to hold the snow, thus furnishing protection to the alfalfa. If seeded without a nurse crop and cut late, these strains frequently kill out so badly during their first winter as to necessitate immediate plowing up.

Grimm alfalfa has great germinative energy and makes satisfactory stands with very thin seeding. It may be sown either with or without a nurse crop; but preferably without, using not more than 15 pounds of seed per acre.

In the North and Northwest, Grimm begins effective growth earlier in spring and continues later into the autumn than any of the numerous kinds with which it has been compared, but South Dakota No. 167, the so-called Baltic alfalfa, resembles it closely in this respect. Often it is ready to be cut when other kinds are yet only half grown. This ability to utilize to the full the rather short growing season of our northern country, combined with unusual hardiness, is of great value.

The physiological factors involved in the early and late growth of Grimm alfalfa have not yet been studied. It no doubt has most intimate relation to the faculty of prompt response in spring to growth-producing stimuli. Similarly, prompt reaction to conditions tending to produce dormancy in autumn is believed to have much to do with the winter hardiness of the variety. The adjustment of Grimm alfalfa to the climatic conditions that prevail in the Northwest is such that it utilizes available growing temperatures to the full limit. On the other hand, when cold weather really sets in, the variety passes quickly from active growth into its resting state. This physiological adaptation of quick response at the right time may readily be the effect of natural selection in a climate which has very marked seasons and where the transition from one season to another is a quick one. The preliminary observations that have been made indicate that the temperature relations of our important crop plants offer an attractive and fruitful field for investigation.

The hardy Grimm alfalfa and the tender Peruvian variety[a] stand in peculiar contrast in their relative behavior in the Northwest and Southwest. In Arizona, during winter, while the Grimm makes practically no growth, the Peruvian may grow all winter and be ready for first cutting before the end of February, just when the Grimm begins to grow again. On the other hand, the northwestern winter usually kills the Peruvian out completely the first winter after seeding, while the Grimm, when broadcasted or drilled in the ordinary way, rarely suffers to an observable degree. During the intense heat of summer in the Southwest growth is almost wholly arrested in the Grimm, but continues without interruption in the Peruvian. These differences have been explained[b] as due to differences in the location of the zero point of growth of the two varieties. Peruvian has a low zero point and fails to become dormant as the weather grows cold. Grimm has a higher minimum and becomes dormant promptly in autumn, thus escaping injury when really cold weather arrives.

These points illustrate in a measure how complex the temperature relations of alfalfa are, and also the great acclimatizational possibilities of the crop when grown for a long time under different sets of climatic conditions.

Ability to begin growth promptly in spring is of especial importance to alfalfa growing in the North. This was pointedly shown in the experiments at Indian Head, Saskatchewan. During the winter of 1905–6 (Table XXVII) 5 kinds killed out so badly that they had to be plowed up. Of the 4 kinds that were left only the Grimm made

[a] Brand, C. J. Peruvian Alfalfa: A New Long-Season Variety for the Southwest. Bulletin 118, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1907.

[b] Brand, C. J., op. cit., pp. 8–14.

a first crop that was worth cutting. It yielded over 3½ tons of hay per acre during the season of 1906, while the best of the other strains produced only a little over 1¼ tons.

The same conditions were in evidence in Fayetteville, N. Y., where Turkestan No. 11211 maintained almost as good a stand as Grimm. But in 1906, while the former produced only 3,340 pounds of hay per acre, the latter yielded 7,450 pounds.

SEED-PRODUCING CAPACITY.

Ability to set seed freely is of the greatest importance in bringing about the extension of a valuable variety of alfalfa. The statement has frequently been made, without proper foundation in fact, that Grimm alfalfa is a poor seeder. If this were true, the wide use that should be made of it would be almost impossible of attainment. Fortunately, this is not the case.

Under favorable conditions Grimm alfalfa has proved to be one of the most prolific in seed production. Wheeler's results at Highmore and Mitchell, S. Dak., have been of especial interest. About 2 ounces of seed of South Dakota 162, which is the Grimm, were sown in a cold frame in the early spring of 1907. Later something over 4,000 plants of the variety were transplanted to about four-tenths of an acre of ground. In September this area yielded about 80 pounds of seed, which is at the rate of 200 pounds per acre. Wheeler's plants were set out in rows with 1½ feet between plants and 3 feet between rows. During 1909 he harvested as much as 200 pounds of seed that traces its ancestry back to an individual plant.

Similar results have been obtained by Mr. A. C. Dillman,[a] of the Office of Alkali and Drought Resistant Plant Breeding Investigations, on the experiment farm at Bellefourche, S. Dak., conducted by the Office of Western Agricultural Extension Investigations. Mr. Dillman found that Grimm alfalfa was "superior to all other stocks tested, in seed production, hardiness, and in forage type of plant." His Grimm selections gave the highest yield of seed per individual plant of any of the varieties in his work. Five hundred plants in rows with 21 inches between plants and 42 inches between rows yielded at the rate of 260 pounds per acre. Furthermore, the Grimm plants also gave the highest yield of hay per individual plant.

Another example of the vigor of Grimm alfalfa in seed production occurred in plat No. 16 (Pl. II, fig. 2), at Dickinson, N. Dak., during the past season. After passing through the winter of 1908–9, which was so destructive to ordinary alfalfas seeded under similar conditions, this plat, which contained one-tenth of an acre, yielded

[a] See "Breeding Drought-Resistant Forage Plants for the Great Plains Area," Bulletin 196, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910, pp. 12–20.

33.6 pounds of clean seed. This is at the rate of 336 pounds or 5.6 bushels per acre.[a] This plat was sown in rows 3 feet apart.[b] In a number of other authentic cases that have come under the writer's observation, Grimm alfalfa in the North has outyielded in seed all other kinds under identical conditions.

The only basis that exists for the statement that Grimm is inferior in seed production lies in the fact that seed has been scarce, hence expensive and hard to get. This meagerness in the supply of seed depends directly on the character of the summer weather that generally prevails in Carver County. As long ago as 1867 Mr. Grimm produced 480 pounds of seed from about 3 acres. There is rarely a year when some seed is not produced, though most seasons are unfavorable for maximum crops. The second growth is generally left for seed-producing purposes and it often happens, as was the case during the summer of 1909, that the alfalfa blooms profusely, giving promise of a heavy seed crop. Then the weather changes and several rainy and cloudy days occur. The almost invariable result of wet weather is that the flowers blast and fall without forming seed.

Seed production of alfalfa is generally uncertain everywhere, but especially in humid climates. Dry and hot weather seems essential to the production of large seed crops. In Minnesota optimum conditions only come occasionally. This is one of the important reasons why Grimm alfalfa has not spread more rapidly over the North and Northwest, but it is not the only reason.

Ordinary American alfalfa was introduced into California only four years before Grimm brought his alfalfa to Minnesota. Since 1854 the former has covered probably as much as 5,000,000 acres in the western third of the United States.

Since 1858 Grimm alfalfa has covered a total of possibly 3,000 acres, confined largely to one county in the State of Minnesota. Many causes have combined to bring about this marked difference in the area occupied by these two races of alfalfa. A very important one has already been touched upon, namely, the unfavorable conditions for seed production that usually prevail in Carver County. In this connection it

[a] The seed yield of alfalfa in recognized seed-producing sections usually ranges from 3 to 5 bushels per acre.

[b] The seed used on this plat was grown in 1907 by Mr. Gustav Rasche at Westbrook, Cottonwood County, in southwestern Minnesota. This place is about 150 miles from St. Bonifacius, where Mr. Grimm made his first seeding in 1858. Mr. Rasche obtained his original seed from Mr. Henry Peterman, of Waconia, Carver County, in 1893 or 1894, so that this strain has been isolated from the rest of the stock for about fifteen years.

Mr. Peterman deserves mention as one of the farmers who early realized the value of Grimm alfalfa and who did much to promote its cultivation by saving seed and distributing it among his neighbors.

must be said that very often in years when the seed supply was ample the local demand was so small that in several cases rather large quantities of seed were shipped to Minneapolis and sold at the price commanded by ordinary alfalfa. It seems likely that this early lack of appreciation of the value of Grimm alfalfa was based on the fact that for many years its cultivation was precarious. A period of nearly twenty years was required to free the foundation stock from nonhardy individuals. As late as 1875 what might be termed wholesale winterkilling still took place. This process of purification, to which the writer has for several years in correspondence and conversation applied the term "selective acclimatization," is not yet complete.[a]

Grimm alfalfa has now become so hardy that in recent years there has been less elimination of unfit lines of descent than during the early years. Nevertheless, weeding out still takes place in winters of unusual severity in any particular respect. A case of this kind was witnessed in 1905–6, when an exceedingly moist autumn with almost 2 inches of rain and a high mean temperature for November changed suddenly to winter with a temperature of −8° F. on the last day of that month, followed by an almost snowless December.

DROUGHT RESISTANCE.

The question as to whether Grimm alfalfa is especially valuable because of drought resistance is still undecided, though it has given good results in Minnesota in very dry years. In experiments under dry-farming conditions near North Platte, Nebr., in the Panhandle of Texas, and near Nephi, Utah, it has shown no marked superiority in this respect. In 1907, at North Platte, 4 strains of ordinary American alfalfa outyielded it. These included seed from Nebraska, Kansas, Colorado, and the Panhandle of Texas. Seven other strains, including 2 Turkestan samples, Poitou alfalfa from France, Texas alfalfa from Grayson County, Utah, irrigated and nonirrigated, and Montana irrigated alfalfa, gave practically the same yield as the Grimm. The rainfall of 1907 at North Platte was 19.61 inches, about an inch above normal. In 1908, with practically 20 inches of rainfall, 6 strains gave considerably better yields than the Grimm, 6 about the same or slightly better, and 6 lower yields.

[a] The hardiness of Grimm alfalfa has now become so well fixed that recently a belief that it was always as hardy as it is now has gained some ground. Had this been the case it seems likely that the experience with ordinary alfalfa would have repeated itself and this crop would occupy as prominent a place in the agriculture of the North and Northwest as it now does in that of the West and Southwest. Alfalfa has been grown in Minnesota twenty years longer than in Kansas. Kansas now has 1,000,000 acres in round numbers, Minnesota possibly 5,000 acres all told.

Grimm has been grown at the South Dakota substation at Highmore since 1905. The precipitation for the years 1905 to 1908, inclusive, was as follows:

TABLE XXIX.—*Precipitation at Highmore, S. Dak., 1905–1908.*

Years.	Precipitation (inches).	
	Growing season (April to August).	Annual.
1905	21.4	26.4
1906	17.5	24.9
1907	11.3	17.3
1908	16.0	22.4

The normal annual rainfall for Highmore is a little more than 17 inches, while the growing-season normal is 12.25 inches. Only the year 1907 was dry enough to give any test whatever of drought resistance. No report has been issued on the work of that year, but Grimm is said to have given fully as good results as the strains that were grown in comparison with it.

These data indicate that Grimm alfalfa offers no particular advantage with respect to drought resistance as compared with our ordinary strain, hence its use should be confined to the regions where cold resistance is of primary importance and to the northern Great Plains where the most successful alfalfa must be both cold resistant and, in a measure, drought resistant.

SUMMARY OF BEHAVIOR.

By way of summarizing the account that has been given of the behavior of Grimm alfalfa it may be said that in the North its effective growth begins earlier and continues later than that of any other strain that has been successfully cultivated in this area. In Minnesota it usually produces three good hay crops and enough additional growth for pasture or for hog feed. It has unusual vigor in seed production, and under equal conditions in the Northwest matures its seed earlier and gives higher yields than any other kind, with the possible exception of South Dakota No. 167. With reference to its drought resistance it may be said to be up to the average in this respect, though it has not proved superior in any of the writer's experiments.

THE POSSIBILITIES OF GRIMM ALFALFA.

Alfalfa is one of the greatest wealth producers among our farm crops. In a little more than fifty years its value to American agriculture has increased from nothing to about $150,000,000 per year.

After deducting the cost of labor, the depreciation in machinery, and all other expenses legitimately chargeable to cost of production, what remains of this annual value would pay more than 5 per cent on an investment of $1,500,000,000.

The average yield per acre of alfalfa for the whole United States is over 2½ tons per acre. According to the figures of the Bureau of Statistics of the Department of Agriculture this is twice as great as the average for all other kinds of hay.

At present the great benefits that come from the cultivation of alfalfa are enjoyed almost exclusively by the western and southwestern third of the United States. In an area including nearly all the farming lands north of the forty-second parallel between the Atlantic and the Rockies, in both Canada and the United States, alfalfa is an important desideratum. On this side of the Canadian line the total area concerned is fully 800,000 square miles, in which probably not more than 75,000 acres of this valuable crop are now grown.

The existence of this condition is due almost solely to lack of seed of a variety that can be depended upon to endure the trying weather of the fall, winter, and spring months.

With an area of a little over 80,000 square miles, where our so-called ordinary American alfalfa proved so readily adaptable, Kansas alone has, in round numbers, 1,000,000 acres of alfalfa. Minnesota, with a larger area than Kansas, probably has less than 5,000 acres all told. North and South Dakota, with a combined area almost twice that of Kansas, have possibly 10,000 or 15,000 acres between them.

The establishment of a successful alfalfa industry in the North and Northwest such as exists in Kansas will mean the addition of millions of dollars to the annual value of farm products of these regions. In the Northwest especially, with the passing of wheat growing, there is great need for alfalfa as a basis of beef and pork production and for dairying purposes. If Kansas, with an area of something over 80,000 square miles, produces an alfalfa crop having a farm value of about $6,000,000 annually, what may we not expect in an almost virgin area of 800,000 square miles?

CONCLUSION.

It now becomes a matter of the greatest importance to propagate a sufficient supply of seed to grow Grimm alfalfa generally in the area to which it is suited. Only by a determined effort can a successful alfalfa industry be established in the North and Northwest. Conditions with reference to seed production are decidedly unfavorable, and inability to obtain seed has been the greatest barrier in recent

years to the wide utilization of Grimm alfalfa. A number of public and private agencies are at present attempting to produce supplies of seed. The most that can be hoped for from present efforts will fall far short of proving adequate to the demand.

No reliable figures whatever are available as to the acreage of Grimm alfalfa now in existence. It can, however, be safely said that it does not exceed 3,000 or 4,000 acres. While this is a comparatively small acreage, it is a great step toward the ultimate goal. In the case of no other variety of proved hardiness, equal or nearly equal to that of the Grimm, are as many as 100 acres available as a basis for an industry.

It is in a measure a public duty for growers having Grimm fields to produce as much seed as possible in order that it may be sold at a price within the reach of every northern farmer. Those who now have fields or plats of Grimm should grow seed whenever possible, even if so doing sometimes causes a loss to them as compared with the returns from hay production. Farmers who are experimenting with Grimm and who now have poor stands from one cause or another are advised when plowing up these fields or plats to transplant the crowns into rows on well-prepared ground, and to utilize these rows for seed production. The selection which such plats have undergone undoubtedly gives added value to the seed produced.

Certain precautions must, of course, be taken to insure success. Of these the following seem the most important:

(1) The use of genuine seed.
(2) Proper tillage methods.
(3) Inoculation.
(4) Isolation of seed plats from other nonhardy kinds.

Experiment stations, seedsmen, individual farmers, and seed breeders' associations, such as the Wisconsin Agricultural Experiment Association and the Minnesota Field-Crop Breeders' Association, should take up the work of producing seed at prices within the reach of every intending grower. In addition, seed growers' unions might be organized to advantage.

Farmers who desire to sow Grimm alfalfa but can not obtain seed enough for acreage plantings should purchase smaller quantities, and produce the seed they require by means of seed-increase plats, or by sowing in cultivated rows, as described in Circular 24[a] of the Bureau of Plant Industry.

In selecting a piece of ground for use in growing seed care should be taken to see that it is well drained. In most of our northern

[a] Brand, C. J., and Westgate, J. M. Alfalfa in Cultivated Rows for Seed Production in Semiarid Regions, Circular 24, Bureau of Plant Industry. Copies of this circular can be secured without cost by application to the Secretary of Agriculture, Washington, D. C.

country, in order to insure desirable dryness in summer, it may be advisable to select a rather light soil. Seeding can be done with almost any of the ordinary garden drills, the rows being left far enough apart to allow cultivation with a horse cultivator. The best crop to leave for seed varies from year to year with the season. The second crop has often been used in Carver County with fair success. The principal point to bear in mind is that a period of hot, dry weather is most favorable to seed production. If in any section such periods recur with regularity during the summer, cutting or clipping should be timed accordingly.

The potential value of Grimm alfalfa, as indicated by the experiments of the Bureau of Plant Industry, the State experiment stations, and individual farmers in the North and Northwest, is so great that no effort should be spared to bring about its general use in the area for which as indicated by experiments it is especially valuable.

SUMMARY.

The establishment of a successful alfalfa industry in the North and Northwest, such as exists in Kansas, Nebraska, and the States farther west and southwest, will mean literally the addition of millions of dollars to the annual value of the farm products of this region.

Alfalfa is one of the greatest wealth producers among the farm crops of the United States. In a little more than fifty years the value of its product has increased from nothing to about $150,000,000 per year.

At present the enormous benefits accruing from the growing of alfalfa are enjoyed almost exclusively by about one-third of the total area of the United States. North of the forty-second parallel, between the Atlantic and the Rockies in both the United States and Canada, very little alfalfa has been grown in the past. In the United States alone the area concerned amounts to about 800,000 square miles. Almost the sole reason for the absence of an alfalfa industry in this great area has been the lack of a variety adapted to endure great cold and other attendant adverse conditions.

In Grimm alfalfa it is believed that the basis of a successful alfalfa industry in this area exists. This strain is very much hardier than the ordinary kind obtained from Kansas, Utah, and elsewhere, and there is even strong reason to believe that it is the hardiest known form of the cultivated plant. It not only endures extremely low temperatures with or without snow and other untoward conditions, but it can be cut with safety later in the fall and will bear more abuse in the way of pasturage than any other kind thus far grown in comparison with it.

There are cases on record where Grimm alfalfa has borne temperatures as low as −38° F. with practically no snow covering without serious loss of stand. There is a small field containing possibly half an acre in Carver County, Minn., to-day more than 40 years old.

There is some disagreement among investigators as to how Grimm alfalfa attained its great hardiness, but there is no difference of opinion as to the fact that it is hardy. The evidence submitted in the present paper indicates that Grimm alfalfa came by its hardiness through selective acclimatization.

The foundation stock of Grimm alfalfa was brought to America in 1857. The uphill struggle which this strain has carried on can be more readily understood when we realize that common alfalfa, which was brought in from South America only three or four years before the Grimm, has extended itself over perhaps 5,000,000 acres, while the Grimm has covered less than 5,000 acres.

Grimm alfalfa came from the vicinity of the little village of Külsheim, near Wertheim, in the Grand Duchy of Baden, Germany. The winter months (December, January, and February) in this region are not quite as cold on an average as November in Minnesota, where Grimm alfalfa has now been grown over fifty years. A 35-year record exists for Wertheim. Only once in this time has a temperature of less than −20° F. been experienced. Only 13 of 35 winters have had temperatures below zero, while 22 have had minima ranging from 2° F. to 16° F. During the same years (1873–1907) St. Paul has never experienced a winter with a minimum as high as −10° F.

That Grimm alfalfa should suffer from winterkilling in its transfer from such mild to such severe conditions was inevitable. That it is still undergoing selective acclimatization is shown by the numerous experiments reported on in the present bulletin.

The region surrounding Grimm's old home and the adjacent parts of Wurttemberg and Bavaria have been for several centuries the chief seat of production of "alt-deutsche fränkische Luzerne," a variety highly prized in southern Germany because of its superior hardiness as compared with the French and other south European alfalfas. The writer has been fortunate in obtaining a number of samples of this old Franconian strain, one coming from within 6 miles of Wendelin Grimm's old home.

It is not possible to assert positively that "alt-deutsche fränkische Luzerne" is the progenitor of Grimm alfalfa, but it seems altogether likely that this is the case.

Nevertheless, it would be unwise to import seed directly from the original source, expecting that it would behave the same as the Minnesota-grown seed. In the nursery-row experiment at Dickinson, N. Dak., a row of Grimm alfalfa killed out less than 3 per cent, while an

adjoining row of old Franconian alfalfa under conditions that might be termed absolutely identical killed out 75 per cent.

The great hardiness, and consequently the great potential value of Grimm alfalfa, has been amply substantiated by the investigations of the Bureau of Plant Industry and by the independent experiments of the Minnesota, South Dakota, North Dakota, and Montana experiment stations. Further corroboration exists in the experience of a considerable number of northern farmers, who have time and again planted seed of ordinary strains of domestic and foreign origin only to have their stands gradually deteriorate to a point where they were no longer profitable and had to be plowed up, and who have subsequently sown Grimm and obtained enduring stands.

It now becomes a matter of the greatest importance to propagate a sufficient supply of seed in order that Grimm alfalfa may be generally grown in the area where it is most valuable. Resistant as the strain is, it still suffers slightly in winters of unusual severity.

Only by determined effort can a successful alfalfa industry be established in our cold northern country. Farmers who have fields or plats of this strain should grow seed whenever possible, even if doing so sometimes causes a loss to them as compared with hay production.

Grimm alfalfa grown for seed should not be grown in close proximity to other tender sorts, as crossing goes on very freely and there is strong evidence for believing that the hardier strains are weakened thereby, and vice versa.

In his annual report for 1907 the Secretary of Agriculture predicted that the further extension of alfalfa growing on large areas is a prize that will be worth hundreds of millions of dollars yearly. With due persistence and an intelligent use of present knowledge, the North and Northwest can now begin to collect at least a part of their ultimate share of this prize.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—A field of Grimm alfalfa 25 to 30 years old on the Bender farm near Chaska, Minn. This shows partially the accumulated selective effect of the winters and other trying conditions which the field has endured. Not all of the plants are as old as the stand itself, a fact which is no doubt due to the thickening up of the stand brought about by seed that has fallen upon the ground from time to time and germinated. September, 1909. Fig. 2.—Winter resistance of Montana and Grimm alfalfa compared. The two plats shown in the foreground are both 2 years old. The one at the right is from seed grown in the Yellowstone Valley near Billings, Mont.; the one at the left is from Grimm seed originally produced in Carver County, Minn. These plats are on the Minnesota experiment station farm at St. Anthony Park. Photographed by Mr. H. D. Ayer, August, 1909.

PLATE II. Fig. 1.—An 11-year-old field of Grimm alfalfa on the Kelm farm, near Excelsior, Minn. It retains from 75 to 80 per cent of the stand. The part of the field in the foreground shows third growth; that in the background, second growth, left for seed. September, 1909. Fig. 2.—A plat of Grimm alfalfa sown in rows 3 feet apart for seed production. The parent of the seed used on this plat was produced in Carver County in 1893, taken to Cottonwood County, Minn., about 150 miles distant, and seeded there in 1894. The original plat is still in existence, though it has produced seed about ten times in fifteen years. The stand has grown gradually thinner and was quite badly injured during the winter of 1902–3. The plat shown in the figure is at Dickinson, N. Dak., and suffered practically no winterkilling during the winter of 1908–9, when the many varieties in the experimental nursery marked by the white stakes in the near distance at the right showed a great range of injury. (For details of this experiment, see Bulletin 185, Bureau of Plant Industry, 1909.)

FIG. 1.—A FIELD OF GRIMM ALFALFA 25 TO 30 YEARS OLD ON THE BENDER FARM, NEAR CHASKA, MINN., SEPTEMBER, 1909.

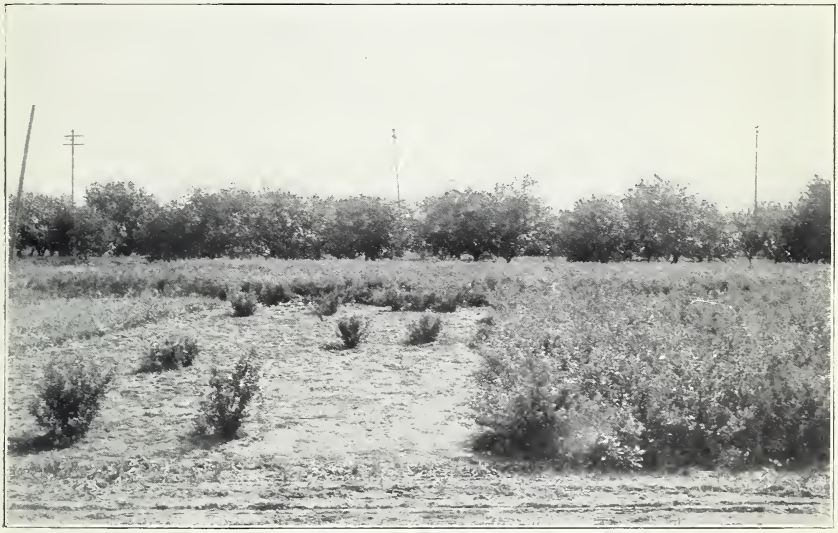

FIG. 2.—A 2-YEAR-OLD PLAT OF MONTANA ALFALFA (AT THE LEFT) COMPARED WITH STAND OF GRIMM ALFALFA OF SAME AGE (AT THE RIGHT), ST. ANTHONY PARK, MINN., AUGUST, 1909.

FIG. 1.—AN 11-YEAR-OLD FIELD OF GRIMM ALFALFA ON THE KELM FARM, NEAR EXCELSIOR, MINN., SEPTEMBER, 1909.

FIG. 2.—A PLAT OF GRIMM ALFALFA, SOWN IN ROWS 3 FEET APART, AFTER THE TRYING WINTER OF 1908-9, DICKINSON, N. DAK., JUNE, 1909.

In the nursery, whose location is shown by the white stakes at the right, 68 strains were winter-killed, an average of 78 per cent.

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